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MANPRINT Methods Monograph: Aiding the Development of Training Constraints

Jonathan D. Kaplan, Editor

U.S. Army Research Institute

J. Thomas Roth, Ronnie E. Warm, and Joseph Peters

Applied Science Associates

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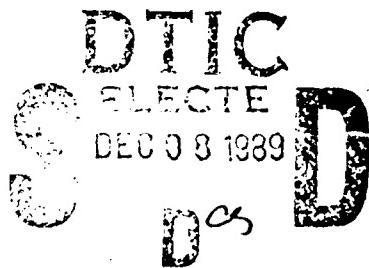
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Horizons Technology, Incorporated

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Science Applications International Corporation



June 1989



**United States Army Research Institute
for the Behavioral and Social Sciences**

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**A Field Operating Agency Under the Jurisdiction
of the Deputy Chief of Staff for Personnel**

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for the Department of the Army

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FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) is developing methods to aid in the successful integration of soldiers and their equipment. Methods are only as effective as their originating concepts. As part of this effort, ARI has defined the requirements for writing a series of detailed concept papers. These papers will serve as conceptual underpinnings and as the first stage of the program for building successful integration methods.

This monograph describes three alternative concepts for building a method to aid in predicting probable training for a developing weapon system. The resulting description of training will serve to constrain the design of the weapon system. These concepts will serve both as the focus of current system building and as a seedbed for future concepts.



EDGAR M. JOHNSON
Technical Director

MANPRINT METHODS MONOGRAPH: AIDING THE DEVELOPMENT OF TRAINING CONSTRAINTS

EXECUTIVE SUMMARY

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) is conducting a program to develop methods to aid in successfully integrating available operations and maintenance personnel with hardware and software as part of the general MANPRINT process. To do this, ARI defined and produced requirements for six classes of aiding methods. In the first phase of this effort, three alternative concepts were developed for each of the six classes of aiding methods.

This monograph consists of three concept papers. These papers describe alternative concepts for aiding the process of predicting probable weapon system training so as to constrain the design of that weapon system.

Ultimately, the ARI study advisory group selected the concept proposed by Applied Science Associates for implementation. However, each of the three concepts is the result of serious thinking about how to deal with training prediction. As such, all three concept papers may prove of considerable value for future research in this area.

MANPRINT METHODS MONOGRAPH: AIDING THE DEVELOPMENT OF TRAINING CONSTRAINTS

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| John K. Hawley, Earl C. Pence, and Robert E. Robinson, Horizons Technology, Inc. (HTI) | E2-1 |
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| Lawrence O'Brien, Dynamics Research Corp. (DRC) | E3-1 |

**MANPRINT METHODS MONOGRAPH:
AIDING THE DEVELOPMENT OF TRAINING CONSTRAINTS**

Introduction

The U.S. Army Research Institute (ARI) is conducting a research program to develop methods to aid in successfully integrating available operations and maintenance personnel with hardware and software as part of the general MANPRINT process. To do this, ARI defined and produced requirements for six classes of aiding methods. The first four of these methods will aid the integration process by developing information that will be used as system design constraints. This information will be used in requirements documents and will be provided to potential design organizations. The last two of these methods will aid the integration process by providing mechanisms to evaluate system designs.

This monograph consists of three papers on a common subject--How to aid in the development of predictions of training that will constrain system design. Each of these three papers presents a concept for building an aiding method for making these predictions. These methods would all be software based and provide aid without significantly raising their user's workload. All concepts were generated in response to the same Army requirement. To fully understand these concepts, one must first understand the context in which they were developed.

The Army acquires systems as a mechanism for obtaining needed performance. The hardware and software components of most Army systems are operated and maintained by soldiers. Therefore, soldiers are components of those systems. The performance and availability levels of systems are directly related to the performance of the trained soldiers who operate, maintain, and support their hardware and software.

The Army must assume that all trained operator and maintenance crews assigned to given pieces of hardware will produce at least minimally adequate system performance and availability so that commanders will have a basis for making battlefield decisions. Training affects soldier performance and therefore how those soldiers interact with system hardware and software. That being the case, the following two approaches to system design should be considered.

1. Hardware and software components should be selected or designed so that they can be integrated successfully with those training characteristics that are likely to exist when the system is fielded. In this approach, available training becomes a constraint and therefore a driver on system design.

2. Training should be selected or designed so as to lead to successful performance when its recipients operate or maintain specific systems. In this approach, system design becomes a constraint and therefore a driver on training design.

This approach is somewhat unusual in the training world. Typically, what would be developed prior to system design is a method for early determination of training requirements rather than constraints. The logic behind the desire to develop a training constraints aid is based on the observation that when there is a natural, sequential flow to events, following that sequence leads to cost-effective output. Attempting to go contrary to such a flow usually results in low effectiveness, high cost, or both.

Systems ought to be acquired, and therefore designed, to produce mission success. All other aspects of systems acquisition, including training, must lead to this desired end. The training requirements approach must be based upon a reasonably detailed understanding of what the tasks will be that will result in mission success and how those tasks will be performed. Some form of task information can be developed prior to system design, but the knowledge of how tasks are to be performed is a direct function of the system design. That is, in the training requirements approach, training design is driven by system design. One might develop hypothetical designs, and determine their training requirements, but this is not cost-effective if there is a significant amount of time available for requirements determination following the development of the real, initial system design. Usually, there is a large amount of time between initial system design development and fielding, and such an amount should be sufficient for determining training requirements.

That being the case, to make a cost-effective impression on system design, one must use the constraints approach and attempt to drive system design with probable training. Once an initial system design has been made, it can be used to determine required training. When this has been done, the differences between the required and probable training can serve as the basis for a training analysis of costs versus effects of making the required training changes.

This monograph was driven by a requirement to develop alternate concepts for predicting probable training. The three concepts presented were written by personnel from Applied Science Associates Inc. (ASA), Horizons Technology, Inc. (HTI), and Dynamics Research Corp. (DRC). Eventually, ARI chose to complete the development of ASA's concept. However, all three concepts have considerable merit and are quite diverse in approach.

The ASA concept is based upon the notion that the major dimension for predicting training is inertia. That is, the training for new or hypothetical systems is likely to be similar to training for existing systems regardless of the adequacy of the previous training or resource requirements of future training. Based on this approach, the real problem to be solved is how to compare hypothetical to existing systems so as to determine what existing systems should serve as sources of training information.

The HTI concept is based upon the development of two methods, one for determining probable training and one for determining required training. The method for determining probable training is conceptually similar to the ASA notion. The method for determining required training is based upon structuring the detailed views of subject matter experts.

The DRC concept is based upon the notion that the major dimension for predicting training is the current availability of training assets. This concept assumes that training is driven by available numbers of training assets including dollars, and the key to predicting it is to determine what those assets will be.

The three concept papers in this monograph have been paginated as E1, E2, and E3 to delineate them clearly.

MANPRINT METHODS MONOGRAPH:
AIDING THE DEVELOPMENT OF TRAINING CONSTRAINTS
CONCEPT FOR A MANPRINT TRAINING CHARACTERISTICS
ESTIMATION AID (PRODUCT FOUR)

J. Thomas Roth, Ronnie E. Warm, Joseph Peters, Stephen Masterson,
and Eleanor L. Criswell

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CONCEPT FOR A MANPRINT TRAINING CHARACTERISTICS
ESTIMATION AID (PRODUCT FOUR)

SECTION ONE

INTRODUCTION AND OVERVIEW

Background

The U.S. Army Research Institute (ARI) has been, and will continue to be, a key player in the Army's MANPower Requirement INTegration (MANPRINT) initiative. The purpose of the MANPRINT initiative is to ensure that continuous attention and scrutiny is applied to Manpower, Personnel, Training, Human Factors Engineering, System Safety, and Health Hazards Assessment factors during system acquisition. This attention is to assure that newly acquired Army systems will be able to meet their mission objectives with the personnel and training that the Army can provide. A principal goal of MANPRINT is to influence and constrain the systems design process so that only the people that the Army has available will be required to operate and maintain new systems. Too frequently in the past, the opposite has been true. This has led to situations where systems demand unreasonably capable or numerous people for operations and maintenance.

To rationally and effectively constrain the system design process so that MANPRINT goals are met, the Army must provide system designers with defensible MANPRINT parameters which their designs must meet in order to be deemed acceptable. Currently, such parameters are based principally on expert judgments provided by specialists in various disciplines (notably human factors engineering and systems analysis) and by military Subject Matter Experts (SMEs). A significant problem with the use of expert judgments is that opinions and estimates differ among experts. This can sometimes leave the parameters supplied to designers open to question. A further problem with expert judgments is that the process of making such judgments is not systematized, and is therefore not inherently auditible or defensible. Finally, expert judgments vary widely in the data considered and the manner in which judgmental rules are applied. This sometimes makes it uncertain that all relevant aspects of issues and their interactions have been considered.

In addition to problems with expert judgment as a basis for MANPRINT constraints is the fact that many of the constraints must be established very early in the acquisition cycle. This means that estimates are required prior to the availability of analytically-based data on the system to be developed. Frequently, only data on the system's mission and desired characteristics are available at this

time. Techniques for projecting even preliminary MANPRINT requirements during pre-concept and concept development are not well formalized.

The focus of the overall effort of which this paper is a part is to develop the beginnings of a "MANPRINT estimation toolkit." Some of the tools to be developed will be used to identify system MANPRINT constraints early in the acquisition cycle. Other tools will be used to evaluate the extent to which system designs comply with MANPRINT requirements and constraints after the system is designed. Under the present ARI effort, six discrete products will be produced for use in implementing the MANPRINT initiative. This paper presents a concept for Product Four of the six products. The goal of this Product is to provide a means of identifying the types and amounts of training which are likely to be provided by the Army for a new system. This information can serve as a basis for developing training characteristics constraints for a new system. The remainder of this paper details a concept for development of this Product.

Product Philosophy

The overall approach which Applied Science Associates, Inc. and Science Applications International Corporation (ASA/SAIC) have adopted for Product Four is an extension, with great modification, of the Comparison-Based Prediction (CBP) technique. This methodology was pioneered by Tetmeyer (1976) and has been further refined by Klein and Associates in a series of efforts for ARI and the U.S. Air Force (Klein and Weitzenfeld, 1982; Weitzenfeld and Klein, 1982; Klein and John, 1984; Klein, Gordon, Palmisano, and Mirabella, 1985; Klein, 1985). This technique relies on using experience with characteristics of existing systems to project similar characteristics of contemplated systems. For example, cost and effectiveness data for existing training devices versus actual equipment can generate implications for a projected training system. Naturally, some modifications to the data on the existing system must be made. It must be emphasized at this point that Product Four is not conventional CBP. It is a much more powerful technique which shares some general philosophy with existing CBP methods.

The premise behind the choice of this approach is the availability of data on the characteristics of training provided by the Army for many types of systems. It is assumed that what the Army presently does in the way of training is a reasonably valid basis for estimating what will be done for training for new systems. Short of radical innovations in training methods or system interfaces with human operators and maintainers, this is a reasonable assumption. It is also reasonable to assume that any such changes will be gradual, rather than revolutionary. Thus, what is known about the characteristics of training systems that now exist will be used to project what training systems for new-acquisition systems will be like.

Techniques developed to date have some shortcomings as tools for the MANPRINT analyst. Current CBP techniques rely on expert judgment (normally provided by SMEs) to identify and characterize the differences between existing and projected systems. These differences are then used to prepare modified estimates for the projected system based on actual data for the comparison system(s) which are used. Expert judgment has proven reliable as a foundation for the conventional CBP methodology, but has some limitations for use in MANPRINT estimation methods. First, gathering expert opinion is a time-consuming and often expensive process. A constraint upon this Product is that no new organizations or significant increase in workload must be required for the Product to be exercised. Thus, an approach which requires significant amounts of consultation with SMEs to derive comparison estimates is not acceptable.

A second problem with expert judgment is mediation: reconciling the differences in judgments of two or more experts in a defensible way. This is normally performed by the analyst. However, the users of this Product are not expected to be trained predictive analysts. The principal users of this Product are analysts in the Concepts and Studies Branches of the Directorates of Combat Developments at system proponent schools, or Soldier Support Center (SSC) analysts. Such personnel neither have such expertise nor can be trained in conventional CBP methods in order to exercise this Product.

In examining the processes involved in the CBP methodology, however, we believe that the shortcomings of existing CBP techniques can be overcome. Our approach to overcoming these shortcomings relies on two observations.

First, the role of the SME as an expert judge is primarily one of applying definable rules and criteria to identify the extent of differences between some comparison system and the target (new) system. When developing comparison cases for characteristics such as reliability or availability, relatively fine judgments about the differences between comparison systems and the target system are required. Since concern here is with training systems, however, it is likely that a far greater tolerance in comparability will yield acceptable, usable estimates. We believe that it is possible to capture and utilize information on systems and subsystems performance and capabilities, along with general dimensions and tolerances of comparison supplied by SMEs. This information will be used to develop a rule structure which allows the automated development of composite comparison cases, given input of the projected characteristics of the "new" system and its component subsystems. In other words, comparison cases can be developed from a pool of actual cases. The training system characteristics of the projected system can then be projected from the training system characteristics of the systems that make up the composite comparison case.

Second, the analyst's role can be largely automated. Since estimates for a consistent class of characteristics (those of the training system) are to be developed, the guidance and structure

typically provided by the analyst to develop composite comparison cases can be generated once and applied many times. A rule structure for the development of composite comparison cases can therefore be developed and applied. Such a rule structure will provide predictions that will be acceptable and defensible for the vast majority of estimates. A second rule structure will be developed to generate training time and some training resources estimates (e.g., training device requirements). These estimates will be based on characteristics of the training systems for material systems that make up the comparison case. These rule structures are the principal reason that this technique should not be thought of as CBP. The CBP technique relies on specific comparison cases. This technique relies on composite comparison cases for making its predictions.

Equipping the rule structures which comprise the "engines" of this Product with defaults, and providing templates to support input of data on the system for which estimates are required will support rapid, easy generation of training estimates. The robustness of the rule structures themselves will support the development of more refined or sophisticated estimates, when more detailed data are available.

Output Requirements

In order to use the proposed methodology as the foundation for this Product, it is necessary to specifically identify the types of information that we wish to estimate. The information to be produced by the Product should be constrained by two factors:

1. The existence of data for the development of composite comparison cases and descriptive baseline data for training system characteristics.
2. The characteristics of the users of the outputs of the Product and the information that they can most effectively utilize in making design decisions that influence the training characteristics of the system.

As discussed in later sections of this paper, data to develop the necessary databases exist or will be derived during the Product development and evaluation period. The critical question now becomes: "Who are the users of Product outputs, and what are their characteristics that should constrain the information provided to them"?

The principal expected users of Product Four information are the system designers who are responsible for developing the Soldier/System Interface (SSI). The characteristics of the SSI are principal drivers of training needs and requirements, for most or all tasks associated with a system. This is true for all operator tasks, and for many maintainer tasks as well.

What are the characteristics of the users that are relevant to the information that Product Four should provide? First, typical interface designers do not understand the impact of design choices on training requirements and training system characteristics. They generally cannot project or estimate whether design choices will impact training, or whether impacts may be positive or negative. Therefore, desired training system characteristics alone will not be of much use to such users. Such data may, however, be useful to the acquisition community (a second class of users) in assessing potential or desirable training system characteristics. These data may also be useful for evaluating the extent to which the ultimate system designs meet MANPRINT training criteria.

Given that training system characteristics data alone are not of much use to the designer, other classes of data which might prove useful were explored. Since training needs are driven by characteristics of the SSI, information that could influence the choices made in SSI design would be useful to present to the designer-user. Training system characteristics information also has uses in the system acquisition process, and Product Four must produce such information, as well.

The next requirement is to identify specific information that will be of use in constraining SSI design choices. Data which are likely to influence design choices in the desired ways are human factors engineering and other design principles. When such principles are effectively applied, they tend to simplify and rationalize the SSI. This facilitates learning operations and maintenance tasks for a system, which can tend to reduce training requirements. However, simply providing a "human factors bible" for the SSI designer will not be sufficient to realize MANPRINT goals. This approach has been attempted in the past, with noticeably disappointing results. A motivational component and at least a skeleton means of linking design principles to training consequences is necessary, in addition to the design principles themselves.

It was determined that a composite approach could satisfy both the motivational and linkage requirements. The approach chosen is to present exemplar training problem areas (training "high drivers") from the histories of the systems and subsystems used to develop the comparison composite, and explain their impacts on training. In addition, we will present, for each training "high driver," associated SSI design problems which have been the causes of training problems. Along with this information, SSI design principles (or references to where to find those principles and how to apply them) will be presented. To provide context and present a complete "training estimate" package, predicted training system characteristics will also be presented.

These data perform two functions. First, they sensitize the designer to training issues, since the "most probable" training characteristics estimates are presented. Second, they promote (although they cannot constrain in detail) an awareness of effective SSI design principles and the impacts of poor SSI design upon training.

These functions, in combination, provide the SSI designer with an opportunity, and hopefully a motive, to utilize effective SSI design principles when making design choices. Utilizing those principles will work to reduce training system requirements, and meet MANPRINT training goals for the new system.

Overview of the Use of Product Four

Figure 1 illustrates the general nature of the operation of the ASA/SAIC Product Four concept. The following subsection presents an overview of the function and components of Product Four and the user interface with the Product. A highly detailed scenario of the interactions between the user and the Product and the functions performed autonomously by the Product is presented in Section Three of this paper. Section Four discusses, in detail, the Product's data requirements.

The overall function of Product Four is divided into three phases, preceded by Product activation and followed by generation of final outputs. The Product itself contains several integral databases and two "engines" for performing Product functions.

Activation

When Product Four is activated, the user selects either the operational mode, which leads to Phase I, or the Embedded Training (ET) mode. When the operational mode is selected, the user has the option of entering new data or modifying existing input data that exist in system files.

Phase I -- Development of Data Entry Template and Input of Data

This is the input phase of Product Four. In this Phase, relevant performance characteristics of the proposed system and its component subsystems are entered into a data input template. The characteristics that are input are the basis for identification of the comparison system against which training estimates will be developed. The activities in Phase I are:

1. The user selects the class (e.g., Close Combat - Heavy) and subclass (e.g., Tank) of system with which he or she desires to work, based on prompting provided by the Product.
2. User selects a specific or default template, or data model, for data input (provided by the Product; assistance is also provided in template selection).

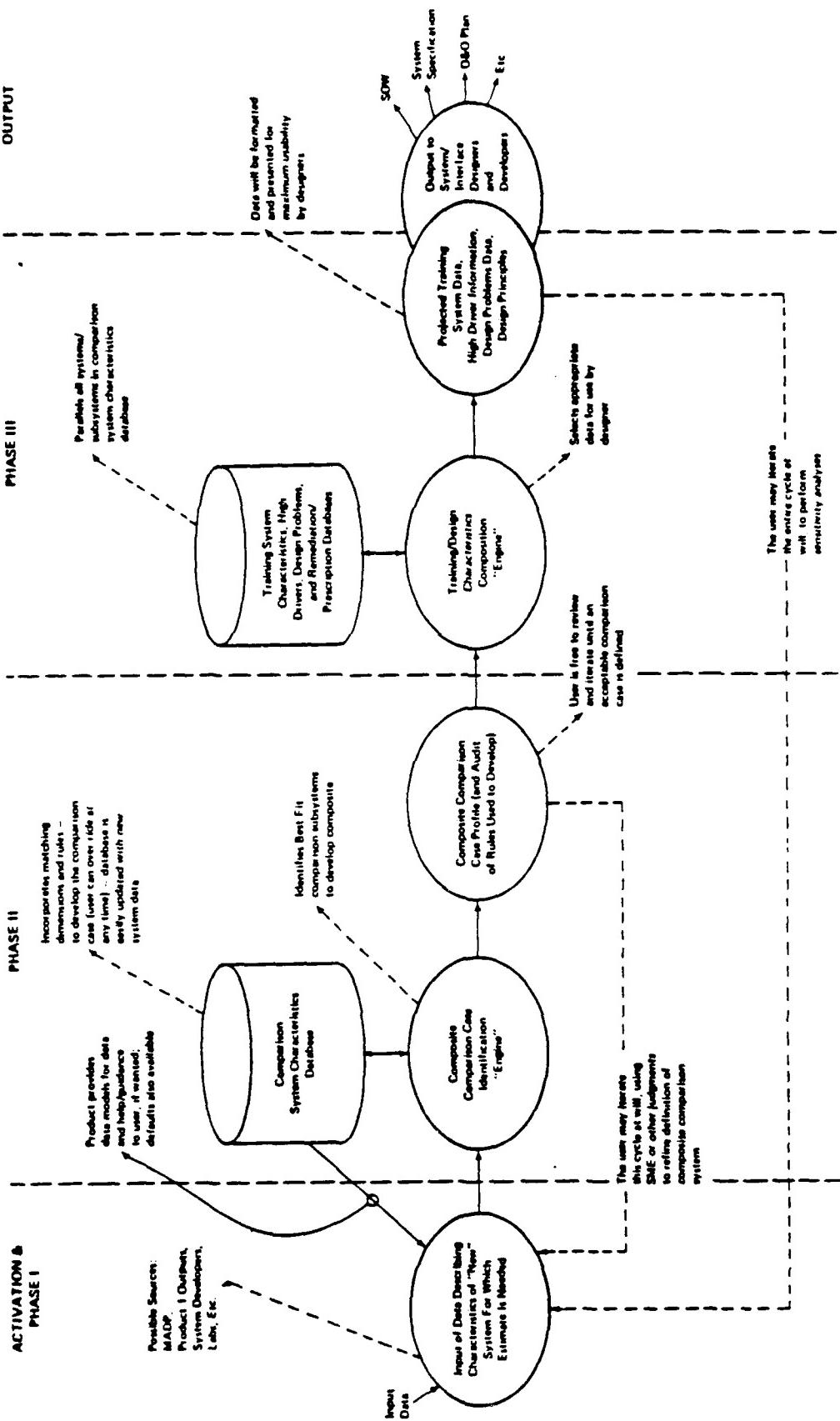


Figure 1. Concept of product four operational structure.

3. User customizes the selected template (with Product assistance, as required) to correspond to data available or to specific characteristics of the proposed system for which the training estimate is desired.
4. Following the data model, the user inputs data which describe the performance characteristics of each subsystem of the system for which the estimate is desired. These data are the basis for the selection of the comparison system.

Phase II -- Comparison Identification and Modification

During this Phase, the Product's composite comparison "engine" identifies subsystems from the resident existing systems database to form a (possibly) composite profile of subsystems on which to base the training characteristics estimate. When the identification is complete, the user has an opportunity to modify the input data, change the subsystems in the comparison system composite, or accept the "engine's" choices without modification. There are two components of Phase II activities:

1. The Product exercises the composite comparison identification engine and selects the best-fit comparison composite for training characteristics estimation; alternatives for each subsystem (with lower figures of merit) are also identified.
2. The user reviews, and modifies if desired, the comparison composite developed by the Product. The user may override the Product's choices in any fashion deemed necessary. SME input to refine the composite may be applied at this point, if available. The user has the option to modify input data to generate other comparison composites.

Phase III -- Training and Design Characteristic Generation and Modification

During this Phase, the Product's training and design characteristic estimation engine selects, from two resident databases, the training system characteristics, design and training problems, and SSI design principles data which are the output of Product Four as a whole. The first database contains training system characteristics information on each system and subsystem that can be used as an element of a composite comparison system. The second database contains training "high driver" information, design problems associated with training "high driver" factors, and references to SSI design principles that (if applied effectively) may ameliorate design (and training) problems associated with the "high driver" factors. The structure and contents of these

databases and their data elements are discussed in Section Four of this paper. Phase III encompasses the following activities:

1. The Product's training characteristic estimation engine retrieves and conditions data for the training characteristics estimate, and makes the data available to the user.
2. The user reviews the output of the training characteristics estimate generation process, and modifies training characteristics as desired, using any available or mandated external inputs.
3. The Product retrieves training "high-driver," design problems, and remediation and prescription data for user review.
4. The user reviews and revises the data as required or desired to customize output for designers or system developers.

Output

The user can select any of the generated training characteristics data or other data (or combinations) for final output. The user selects the desired outputs by responding to Product queries. The selected information is then formatted and output for ultimate use in the acquisition process.

The user is supplied with extensive helps, defaults, data models, and embedded training availability throughout Product Four use. These Product features make it possible to generate at least initial "strawman" training characteristics with minimal data or expertise in computer operation. In addition, the user is completely free to re-enter the Product operation cycle at any point, to modify input or composite comparison data, or to alter output data based on factors not applied in the previous operation of the Product.

Overview of the Remainder of This Paper

The balance of this paper consists of eight sections, as follows:

- Section Two details the information that Product Four will produce as a result of its operation, and the aiding that will be provided for the operational user of the Product. This corresponds to requirement number four for the concept paper in the contract Statement of Work (SOW).

- Section Three presents a detailed discussion of how Product Four will function to produce its outputs, as a detailed scenario including descriptions of user interactions with the Product. This corresponds to SOW requirement five.
- Section Four discusses specific data requirements for Product Four, and details the sources from which data will be accessed or derived, as well as procedures for developing data. This corresponds to SOW requirements two and three.
- Section Five discusses the time required to use the Product Four system to develop training characteristics estimates. This corresponds to SOW requirement nine.
- Section Six describes how Product Four will be developed. This corresponds to SOW requirement one.
- Section Seven describes the means that will be built into Product Four to train its users and facilitate their use of the Product. This corresponds to SOW requirement seven.
- Section Eight discusses our approach to gaining acceptance and use of the outputs of Product Four. This corresponds to SOW requirement six.
- Section Nine discusses our approach to attaining institutionalization of Product Four in the Army context as it presently exists. This corresponds to SOW requirement ten.

SECTION TWO

INFORMATION AND AIDING WHICH PRODUCT FOUR PROVIDES

Product Four provides information and aiding to three general classes of personnel. These are:

1. The actual users of Product Four - the analyst with responsibility for estimation of training characteristics for MANPRINT ("the user").
2. The general system and SSI designers ("the designers") who utilize the outputs of Product Four as targets and constraints in the process of system and SSI design.
3. System developers and managers ("the developers") who use the estimates provided by Product Four as reference and evaluation information in assessing whether system designs meet MANPRINT training goals.

The characteristics of information and aiding provided to each class of personnel is somewhat different. Specifics are discussed in the following paragraphs.

The User

Since this Product represents an attempt to automate a complex process and enable the user (who is not expected to be trained in the nuances of the training estimation process) to make training characteristics estimates, the most detailed assistance is provided to the user. Product Four will provide the following general classes of aiding to the user.

1. Assistance in Developing Input Data. Product Four will provide both default and customized templates or data models for structuring input data that describe the characteristics of the new system for which a training estimate is required. Standardized templates will be provided for each class and subclass of system for which the Product will support estimate development. The templates will include identification of subsystems, comparability dimensions, tolerances, and comparison rules. In all cases, defaults will be available to enable the user to work with preliminary or incomplete data and still be able to derive a "strawman" or first-approximation estimate. Input data developed in each instance of Product use will be retained on file for future use as a template

candidate, or for modification for updates or sensitivity analyses of original estimates. An example of one portion of a data model is shown in Figure 2.

2. Override and Tailoring Opportunity for Comparison Cases.

In some cases, the user may have direct access to SME resources who can critique and suggest modifications to the comparison cases identified by Product Four. Also, the user may occasionally be sufficiently sophisticated or knowledgeable, or presented with external constraints, to modify the suggested composite cases developed by the Product on-line or autonomously. An example of an external constraint is "ten percent less training shall be required overall than for the immediate predecessor system." Each comparison case developed by the system is subject to review and modification by the user at any time, even during intermediate stages of estimate development. Each estimate generated by the Product or modified by the user is retained on file for later retrieval, modification, and change. This supports a high degree of capability for sensitivity analyses and introducing additional factors from external sources (e.g., SMEs, if available) to support training characteristics estimation.

3. Override and Tailoring Opportunity for Product Outputs.

The automation inherent in Product Four cannot guarantee outputs that will be completely satisfactory for all possible purposes. For example, a training system estimate may exceed parameters that have already been established for the new system. Thus, the user needs an opportunity to review, modify, and tailor the training system estimate to meet a variety of conditions. Likewise, the user may have insight into the amount and level of training "high driver" information, design impacts on training, and remediation and prescription information that is acceptable and usable. This information can also be reviewed in detail, and the Product-suggested outputs tailored so that the unique needs of Product output users can be served.

4. Sensitivity Analysis Capability. In many cases, alternate impacts of different assumptions, different input data, or different composite comparison systems upon training system estimates may need to be generated. Product Four enables the user to suspend Product operation in order to modify input or intermediate Product data at many points. Using this capability, the user can explore both the impacts of: (a) varying input data on the comparison systems identified by the product; and (b) varying input or comparison composite case data on the ultimate outputs of Product Four. The product also supports serial iteration through the entire Product function cycle for sensitivity or impact

DATA INPUT TEMPLATE

For New System: AHX (Attack Helicopter)

Inputting Data for Subsystem: Communications

| <u>Characteristic</u> | <u>Template Value</u> | <u>New-System Value</u> |
|-------------------------|-----------------------|-------------------------|
| UHF Radio Power | 200 watts | 200 watts |
| UHF Radio # Channels | 720 | 720 |
| VHF Radio Power | 145 watts | 145 watts |
| VHF Radio # Channels | 320 | 640 |
| HF Radio Power | 100 watts | 125 watts |
| HF Radio # Channels | 240 | 240 |
| Crypto Capability (Sys) | Yes | <_> |

New Data Input

Filename: AHX1NEW.V01

Options: NEXT-SUB DONE HELP ABORT CHK-PNT SAVE-END PRINT
 PREV-SUB

Enter Value at Cursor

Figure 2. Data input template.

analyses. This is done by preserving all input data or comparison case alternatives investigated. This enables the user to maintain an audit trail of sensitivity analyses conducted and make input and output data available as possible templates and data models for future product use.

5. Embedded Training and On-line Helps. Product Four will have a comprehensive embedded training component which will have the capability to instruct the operator in both basic and advanced use of the Product, as well as the underlying methods embedded in the way the Product functions. Training capabilities will also cover the why and how of conducting sensitivity analyses. A context-sensitive on-line help facility, coupled to the embedded training capability, will also be provided by Product Four. Help will always be available to both the novice and experienced user to enable the users to accomplish their goals in using the Product.
6. Override of Product Steps. This option is available for those experienced users who prefer to override steps in Product Four function for direct entry or for other reasons. This option is available at most steps in Product Four function, as indicated in the detailed functional description. Override is accomplished through commands given when the Product is activated.
7. Processing Flexibility. Batch processing and accelerated processing are available for more sophisticated users, or for those desiring to conduct exploratory or follow-up sensitivity analyses or validate databases and product operation.

The Designer

As discussed in the philosophy of Product Four in Section One of this paper, one objective of the Product is to provide information that assists the designer to act in such a fashion as to meet MANPRINT training goals. To reiterate, the information that will be provided for designers is as follows:

1. Training System Characteristics Estimate. An estimate of the training time for all classes of operator and maintainer personnel for which data are available, by subsystem and for the system at large. The training system characteristics estimate will also provide an estimated training device requirements profile (type and number of devices) for training each class of operator and maintenance personnel.

2. Training "High Drivers" Data. The Product will provide the system and SSI designer with critical incident descriptions of cases in the histories of the subsystems which make up the comparison case that represent excessive training requirements. The "high drivers" information will be related to cases where system (or, more specifically, SSI) design is attributed as a principal factor in the existence of training high driver factors.
3. Design Problems Related to High Drivers. Product Four will provide, for each "high driver" example output to users, a diagnosis of design problems which have been implicated as causal factors in creating unnecessary or excessive training. These examples will be as specific as possible, to allow designers to derive object lessons of the impacts of poor SSI or system design upon training.
4. Remediation and Prescription Data. The final elements of information output for designers will be reference to or citation of human engineering design principles which, if applied, might have ameliorated the design problems associated with training "high driver" factors. The purpose of presenting this reference data is to influence design choices toward design characteristics that minimize training needs for the system.

The System Developers

Acquisition and system development personnel have uses for the training system characteristics information produced by Product Four. This information may be useful as (for example) feeder data for developing Organizational and Operational (O&O) plans for the new system. Also, if the training system characteristics data produced by Product Four are accepted, they may be the basis for developing MANPRINT criteria and constraints in acquisition documents, and as reference values for evaluating system design compliance with MANPRINT constraints.

SECTION THREE
PRODUCT FUNCTION

General Features of Product Four Function

The operational structure of Product Four is illustrated in Figure 3. Product Four is functionally divided into three Phases that are described in this Section, preceded by Product activation and followed by output of data. There are certain characteristics (presented in the previous section of this concept paper) underlying all of the phases of Product Four function that add to its ease of application (user friendliness). These characteristics include aspects of the user interface and of the Product's resident databases.

The data requirements as well as the user interface requirements of Product Four are based on the overriding goal to make the Product as user friendly as possible. The types of data needed to develop and exercise Product Four are illustrated in Figure 3. To summarize, they are: (1) input data, (2) comparison systems data, (3) training and design characteristics data, and (4) remediation and prescription data. A basic assumption is that the user of Product Four will have little time or opportunity to find and consult with SMEs in order to apply Product Four. Therefore, Product Four will incorporate subject matter expertise within its resident databases to ensure the at least a "best guess" is delivered to the user. Confidence in Product Four outputs will be a function of the completeness and accuracy of the input data, background knowledge of the user (as reflected by the number of defaults used) and completeness and accuracy of the resident databases. Data included in the Product Four resident databases will ensure that the user will always have a "strawman" output which can be refined as the user sees fit. Therefore, defaults will be available for every user decision required except the type of system for which a training characteristics estimate is desired.

The remainder of this Section presents a detailed description of Product Four function, supplemented with flowcharts that illustrate the functioning of the Product.

NOTE: In the discussion below, functions that are marked with an asterisk (*) are able to be specified by parameter entries when Product Four is activated. When this is done, the detailed, menu-driven interactions associated with inputs that are specified during activation do not take place. This is a feature included for experienced users, to facilitate rapid generation of estimates in (for example) conducting sensitivity analysis.

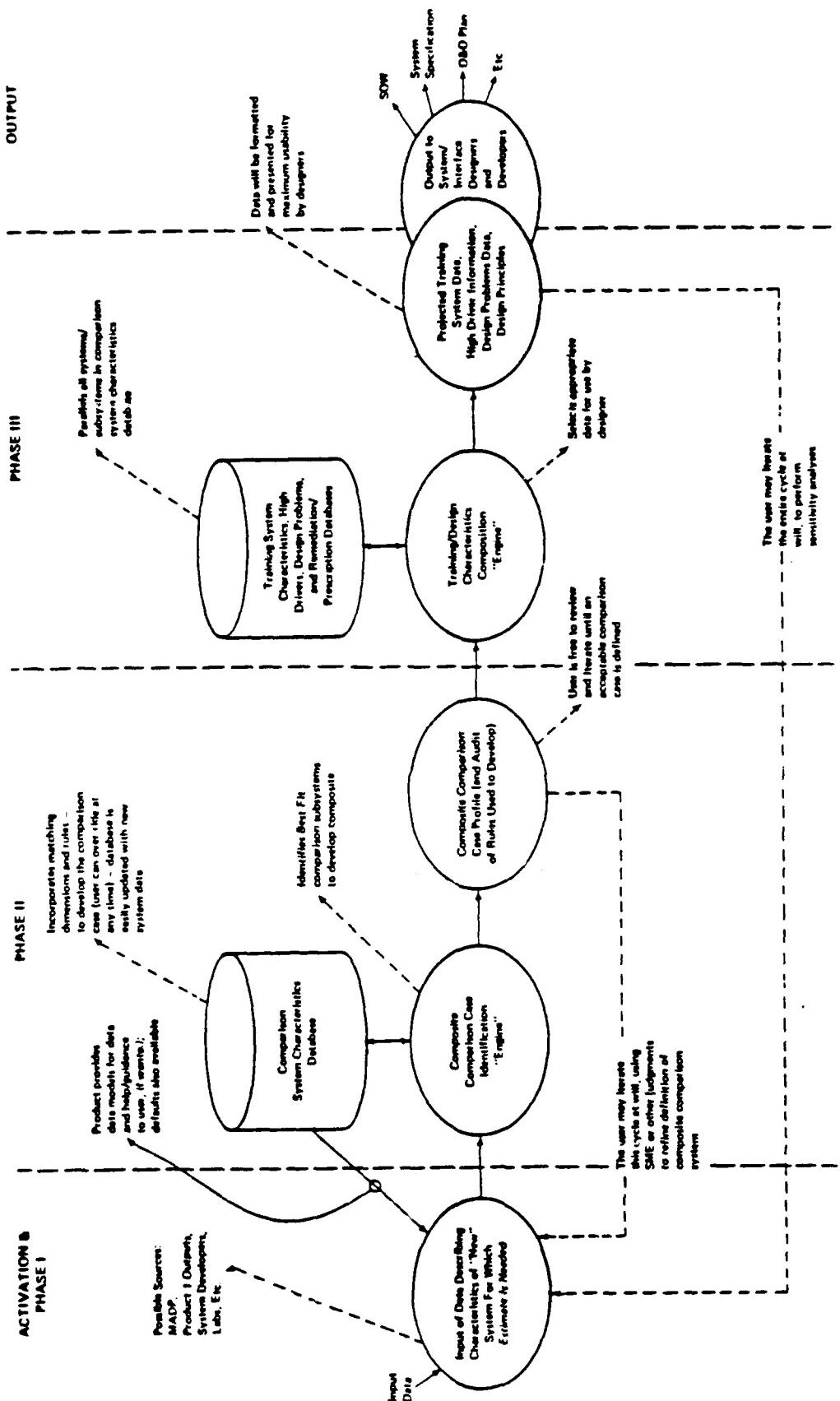


Figure 3. Concept of product four operational structure.

Product Four Activation

The activation of Product Four is illustrated by the flowchart in Figure 4. Upon activation, the Product Four user selects either the ET or operational mode. The ET capability is described in detail in Section Seven. The operational mode takes the user directly into Product functions. The user can exit the operational mode at any point and return to that point at a later time. Once in the operational mode, the user indicates whether or not a new estimate is to be derived. When a new estimate will be developed, the Product automatically takes the user to Phase I. When the user desires to modify existing data or to continue work on an estimate already begun, he or she selects the file to be retrieved. Product Four then begins functioning.

Phase I -- Development of Data Entry Template and Input of Data

Overview

This phase encompasses data model (template) development and data input. The flowcharts in Figure 5 illustrate Phase I functions. During data model development, the analyst enters data associated with relevant performance characteristics (dimensions) of the proposed system and its component subsystems. The principal reason for using templates, or data models, to guide input is to ensure that the input data conform to the types of data and units of measure which are contained in the comparison systems database. When the data model has been completed, data that describe the characteristics of the proposed system and its subsystems are entered in the format of the template. These data are the basis for identifying the comparison case in Phase II.

Outcome

At the end of this phase, the data model is completed, and the performance characteristics and associated values of the component subsystems of the proposed system have been entered.

Detailed Functional Description

Step 1.1 Identification of the class of system for which the estimate is desired.

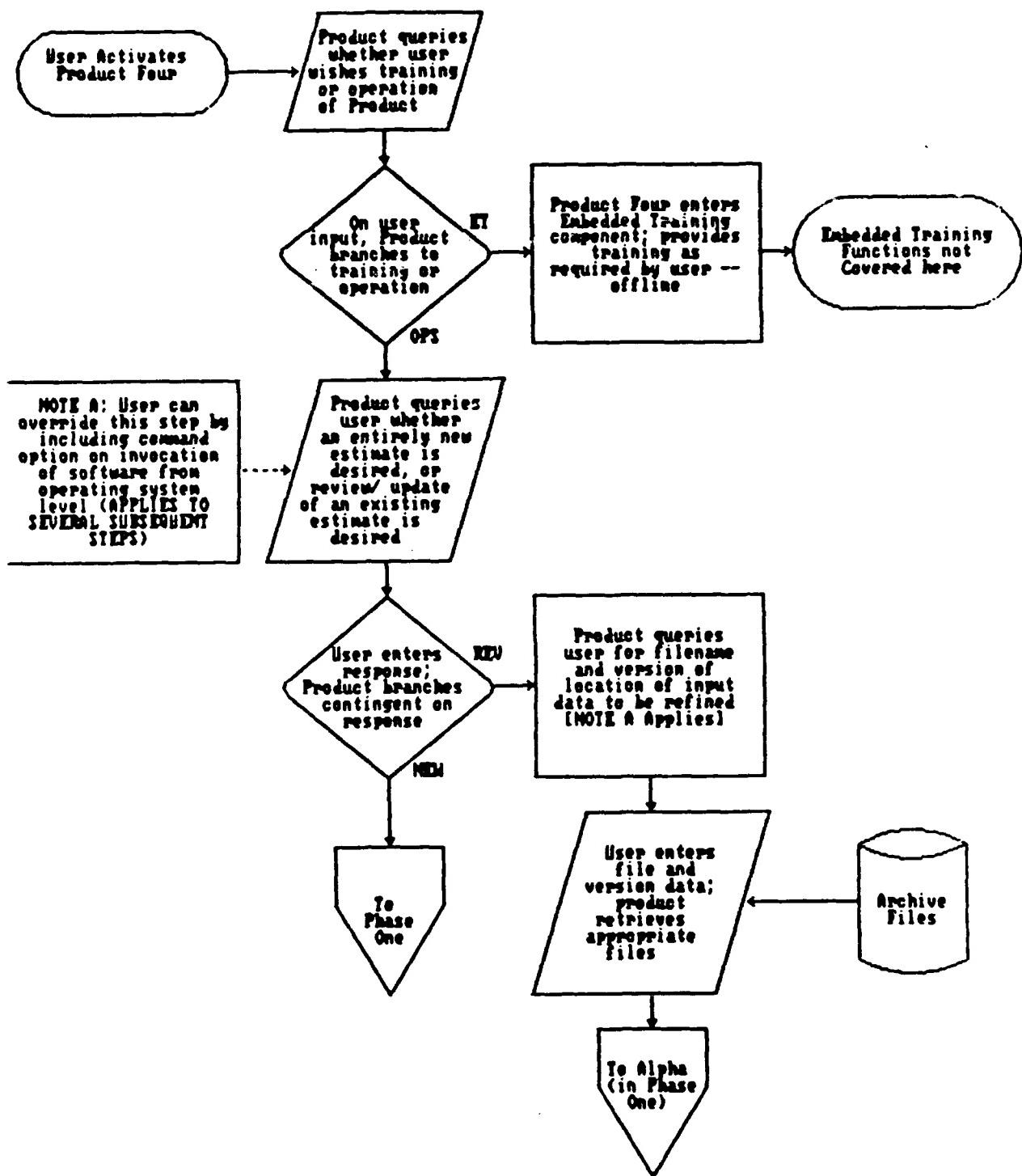


Figure 4. Product activation flowchart.

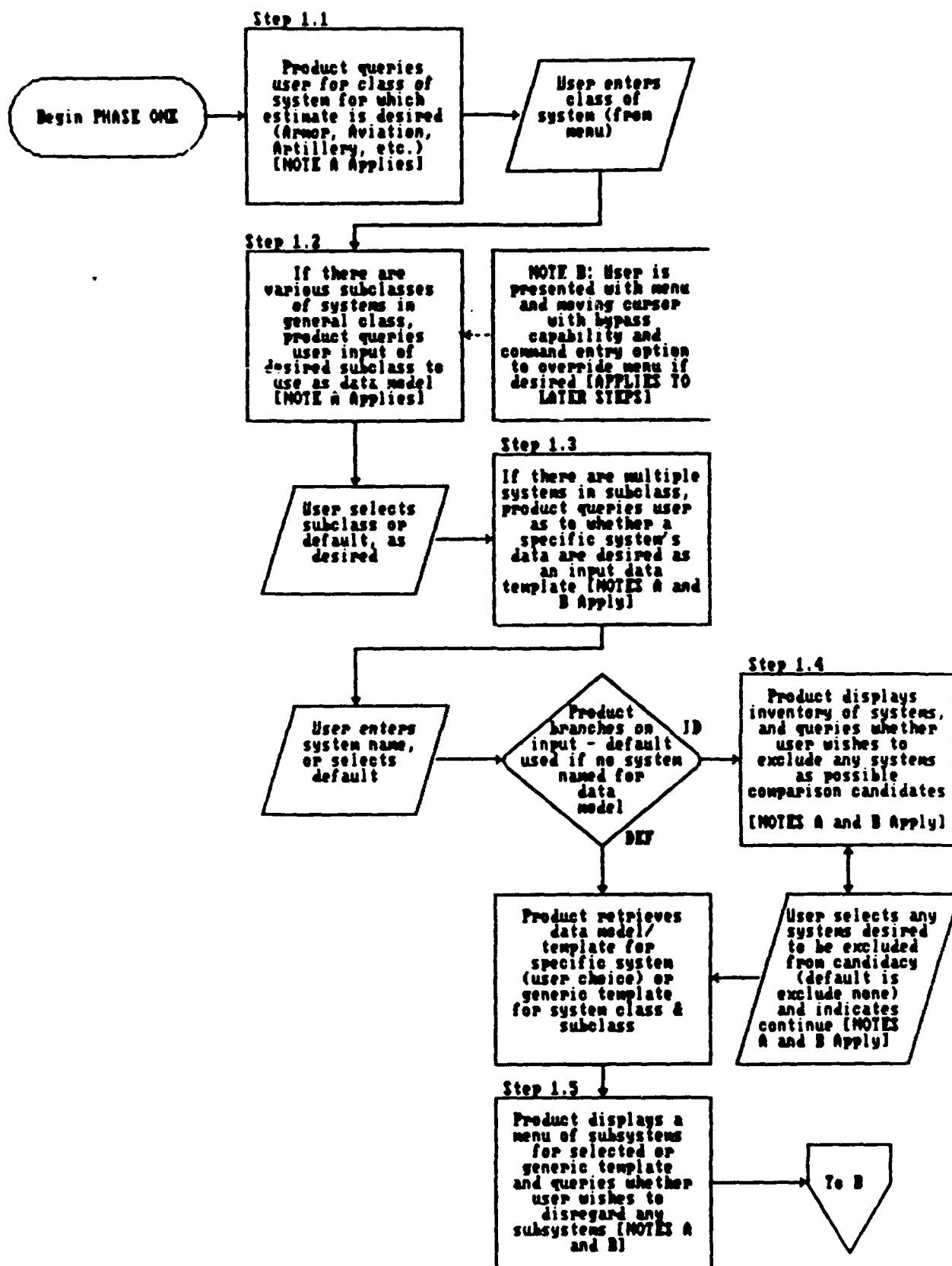


Figure 5. Phase I flowchart.

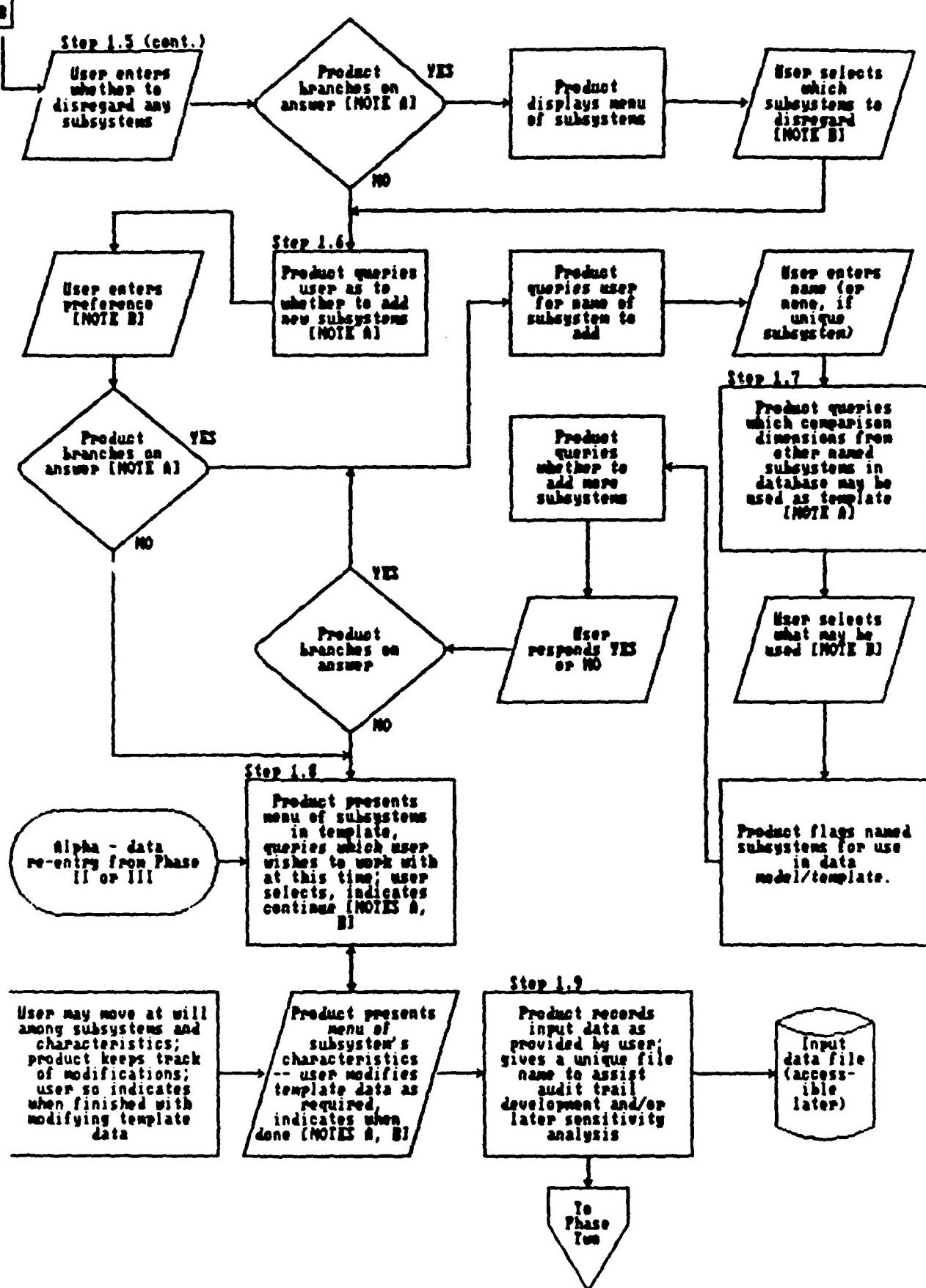


Figure 5. Phase I flowchart (continued).

Rationale: The identification of the proposed system class is necessary for two purposes. First, because selecting a data model template for data entry is made easier if the system class is specified, and second, because data in the comparison systems database is organized by system class.

*Product Action: Presents the user with a menu of classes of systems (e.g., Aviation, Armor, Field Artillery, etc.).

User Action: Selects the class of system for which the estimate is required.

Help Available: In most cases the system class will be obvious to the analyst. For those rare occasions when the class of the proposed system is not immediately apparent, prompts and cues will be provided, including class definitions and examples of systems in each class, to aid in the identification of the appropriate class.

Default: A default option will not be available; the identification of a class of system for data model development is required.

Step 1.2 Identification of the subclass of the proposed system.

Rationale: Once again, the identification of the subclass narrows down the possibilities for the data entry template and potential comparison systems.

*Product Action: Presents the user with subclasses of systems in the selected class (e.g., Attack Helicopters, Cargo Helicopters, Utility Helicopters, Fixed Wing Aircraft, etc. within the Aviation class).

User Action: Selects the subclass required.

Help Available: In most cases, the system subclass will be obvious to the user. When the user cannot determine whether the proposed system falls into one of the presented subclasses, the Product can provide decision aids (through the Help facility) including descriptions of systems included in each subclass.

Default: A default option will not be available; the identification of a subclass of system for data model development is required.

Step 1.3 Selection of initial data input template.

Rationale: Data input must conform to a data model that reflects the types of data and units of measure available in the comparison systems database for the particular class or subclass of system for which the estimate is desired.

*Product Action: Presents the user with a list of systems in the subclass.

User Action: Selects a system whose data will be used as an input data template, or chooses to use a generic template for data input. The next step is not performed if the user chooses to use a generic data model, rather than one based on a specific system, on the assumption that a user who requests a generic data model will not be sufficiently sophisticated to be able to exclude specific systems from comparison candidacy.

Help Available: Lists of systems and their component subsystems in the comparison systems database will be available. In addition, the user can review templates/data models associated with the systems in the comparison systems database as required, to aid in selection.

Default: Data input will be based upon a generic data model corresponding to the subclass of the proposed system.

Step 1.4 Elimination of systems as comparison candidates.

Rationale: The elimination of systems as potential comparison candidates allows the user to directly impact the nature of the comparison to suit the individual estimate under development.

*Product Action: Presents the user with a list of systems in the selected subclass.

User Action: Selects systems to be eliminated as possible composite comparison candidates (if any).

Help Available: None. Users who wish to exclude specific systems as potential comparison candidates are presumed to have reasons for doing so, or to have been directed to do so.

Default: All of the systems in the identified class or subclass will be considered potential composite comparison candidates.

Step 1.5 Elimination of subsystems in the data model that are not applicable to the proposed system.

Rationale: There may be times when the proposed system does not include all of the subsystems in the selected template; the elimination of inapplicable subsystems is the initial tailoring of the input template so that it will eventually reflect characteristics of the proposed system.

*Product Action: Presents the user with a list of subsystems of the system chosen for the data model.

User Action: Indicates subsystems to exclude from the data model (if any).

Help Available: None. Since subsystems are only eliminated when they are not part of the proposed system, it is expected that this step will be easily accomplished without additional help. Users must have available the names of subsystems as part of input data.

Default: All of the subsystems in the selected template will be included in the data model, and are assumed to be present in the proposed system.

Step 1.6 Addition of subsystem(s) to template.

Rationale: The selected input template may not include all of the subsystems in the proposed system. The user has the option of adding new subsystems to the data entry template.

*Product Action: Presents user with a list of the subsystems included in the data template and the option of adding a subsystem.

User Action: User decides whether a subsystem should be added to the template. When a subsystem is to be added, the user enters the subsystem name. If no subsystems are to be added, the next step is not performed.

*Product Action (following user action): If a subsystem is to be added to the template, the Product retrieves and displays the names of all of the systems in the comparison systems database which have subsystems named the same as the subsystem to be added.

Help Available: The user may request a listing of unique subsystem names (from the comparison systems database) and display the list to the user as an aid in specifying a name for the subsystem to be added.

Default: Additional subsystems will not be added to the template.

Step 1.7 Identification of comparison dimensions, values, and tolerances for the template of the added subsystem(s).

Rationale: Comparison dimensions and values must be specified to allow comparison of input data with data in the comparison systems database. This step enables the user to include or customize dimensions and values in the input template that reflect the characteristics of the subsystem to be added.

*Product Action: Presents a list of systems containing subsystems with the same name as the added subsystem, along with corresponding comparison dimensions and values (values identify the units of measure).

User Action: Reviews and selects from the comparison dimensions, values, and tolerances associated with applicable subsystems, selects one system whose data will provide the template, or enters this information independently.

Help Available: Will include prompts and cues for entering and selecting dimensions, values, and tolerances.

Default: A generic template for the added subsystem(s) will be utilized.

Step 1.8 Entry of input data according to the template, by subsystem.

Rationale: The template that exists to this point serves as the model for data input for the system for which the estimate is required. During this step, data is input to reflect the expected characteristics and the comparison priorities of the proposed system.

*Product Action: Presents the user with a list of subsystems currently in the template.

User Action: User selects a subsystem for modification.

*Product Action: Presents the user with a list of the selected subsystem's characteristics, along with the associated units of measure. Figure 6 shows an example of a conceptual input screen for a subsystem.

User Action: User enters specific characteristics data according to the template. User may also assign comparison priorities to each characteristic, or allow them to be equally weighted.

NOTE: The four steps immediately above are iterated until the user has completed entering input data according to the data model.

Help Available: Extensive help messages will be available including: pertinent definitions; reviews of the use of the information to be entered during comparison case development; considerations for making priority decisions; and other (to be determined) prompts and decision aids.

Default: The existing data from the comparison systems database for the subsystem under consideration will be used as is (i.e., without user modifications) as input data for the subsystem of the new system.

DATA INPUT TEMPLATE

For New System: AHX (Attack Helicopter)

Inputting Data for Subsystem: Communications

| <u>Characteristic</u> | <u>Template Value</u> | <u>New-System Value</u> |
|-------------------------|-----------------------|-------------------------|
| UHF Radio Power | 200 watts | 200 watts |
| UHF Radio # Channels | 720 | 720 |
| VHF Radio Power | 145 watts | 145 watts |
| VHF Radio # Channels | 320 | 640 |
| HF Radio Power | 100 watts | 125 watts |
| HF Radio # Channels | 240 | 240 |
| Crypto Capability (Sys) | Yes | < <u>_</u> > |

New Data Input

Filename: AHX1NEW.V01

Options: NEXT-SUB DONE HELP ABORT CHK-PNT SAVE-END PRINT
 PREV-SUB

Enter Value at Cursor

Figure 6. Data input template.

NOTE: Using default values from the comparison systems database is one means by which the user can deal with specific external constraints on training characteristics. For example, a directive may have been issued that specifies that training time for the new system will be some percentage less than that for a particular predecessor system. In such a case, the user can simply default to the predecessor system (by using all of the characteristics and values for the predecessor system), and adjust the training characteristics estimate generated by Product Four to conform to the external constraints.

Likewise, if some knowledge exists that optimum training (whatever that may be) will be provided for a contemplated new system, the user can make a similar sort of adjustment. Although it is difficult to imagine a case where this would be done, Product Four and the user are able to deal with such a situation. In this case, the user might conduct a sensitivity analysis to determine the maximum training time and resources estimates that can be generated for a particular kind of system, and use those values as an initial estimate.

Step 1.9 Data management.

Rationale: The input data must be stored prior to retrieval for use during the composite comparison identification. This provides an audit trail and maintains the input data available for possible later modification or re-use.

User Action: Indicates when the input data for all subsystems is complete.

Product Action: Detects when user has finished inputting data, and creates a disk file that includes the input data in the format of the data model.

Help Available: None. Data management is automatic.

Default: Data management is automatic.

Phase II -- Comparison Case Identification and Modification

Overview

The flowchart contained in Figure 7 illustrates Phase II function. After the data describing the characteristics of the proposed system are entered, the composite comparison engine compares the input data, subsystem by subsystem, with data in the comparison systems database. All of the subsystems corresponding to the class or subclass of the input system are considered potential comparison candidates (with the

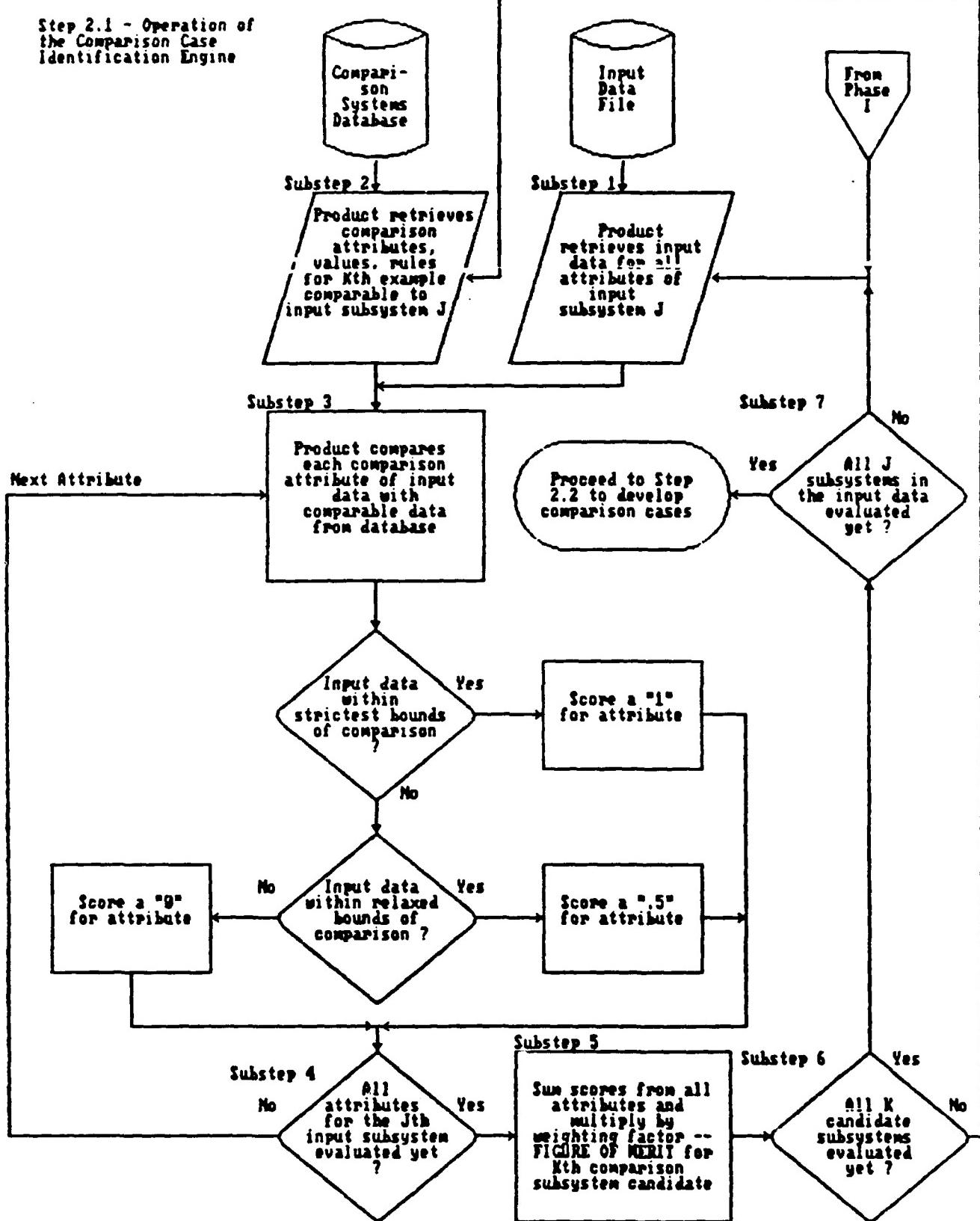


Figure 7. Phase II flowchart.

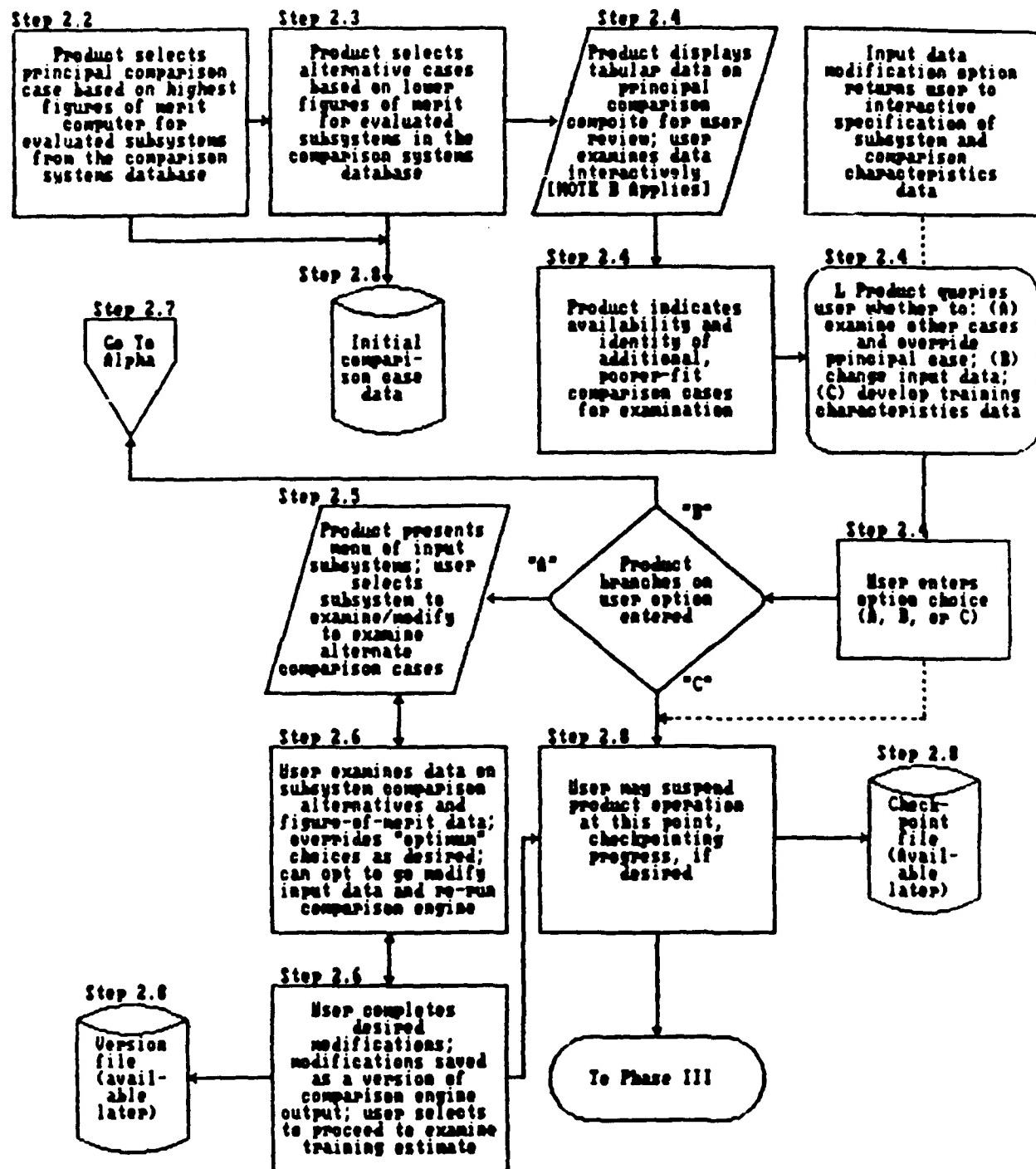


Figure 7. Phase II flowchart (continued).

exception of those explicitly excluded in Phase I). The comparison identification engine selects the subsystems that are the best matches to the input data through a template matching process. Each characteristic of each subsystem in the input data is systematically compared to the applicable subsystems in the comparisons systems database. The template matching is performed according to the comparison rules and tolerances contained in the comparison systems database and the comparison priorities provided by the user.

The template matching process results in selection of the subsystems which most closely approximate the performance characteristics included in the input data. The comparison case identification engine computes a figure of merit or measure of similarity between the input data (on a subsystem basis) and each like-type subsystem in the comparison systems database. The comparison subsystems are each then sorted into order based on the figures of merit computed. In aggregate, the subsystems with the highest figures of merit make up the recommended comparison case from which the training system characteristics estimate is derived.

The comparison case can thus be a composite of subsystems from as many existing systems as needed to fall within the specified performance envelopes of the proposed system. Worst-case estimates will be used when no subsystems in the comparison systems database match the input data, or when performance envelopes cannot be satisfied at all.

After the comparison case identification engine has been exercised, the information generated is presented to the user for review. At this point, the user reviews the subsystems selected for inclusion in the comparison case by the comparison case identification engine. The user can exercise several options following this review. First, input data can be modified and a new comparison case generated to reflect changes resulting from the revised input. Second, the user can accept the comparison case generated by Product Four. Finally, the user may modify the comparison case by substituting different subsystem choices, after reviewing possible choices with lower figures of merit.

Detailed Functional Description

NOTE: Step numbers in the discussion below refer to numbered steps in the Figure 7 flowchart.

Step 2.1 Operation of the comparison case identification engine.

Rationale: The comparison case identification engine is operated to compare each of the subsystems in the input data with every applicable comparison subsystem in the comparison systems database.

User: The user's only responsibility at this point is to indicate that the comparison case identification engine should be

activated. This is normally done by indicating that input of data is complete.

Product Action: Product Four compares the comparison attributes in the input data with those in the comparison systems database, in the following manner:

- Substep 1. Product retrieves the input data for all attributes of input subsystem J (all comparison attributes and associated values).
- Substep 2. Product retrieves comparison attributes, values, and comparison rules for the Kth subsystem example comparable to input subsystem J, from the comparison systems database.
- Substep 3. Product compares each comparison attribute in the input data with each comparable comparison attribute from the comparison systems database, according to the rule for the attribute. If the input data fall within the strictest bounds established by the comparison rule, a "1" is scored for the attribute. If the input data fall within relaxed bounds established by the comparison rule, a ".5" is scored for the attribute. If the input data fall outside of bounds established by the comparison rule, a "0" is scored for the attribute.
- Substep 4. The comparison process is iterated across all comparison attributes established for subsystem J in the input data.
- Substep 5. The scores for all attributes for the Kth subsystem in the comparison systems database are summed and the sum is multiplied by any weighting factor for the input data subsystem that has been input by the user. If no differential weights are supplied by the user, then all subsystems are weighted equally. The resulting value is the figure of merit for the Kth comparison subsystem in relation to the input data for the Jth subsystem.
- Substep 6. The process described in substeps 3, 4, and 5 immediately above is iterated for all K subsystems in the comparison systems database that are comparable to the Jth input data subsystem.
- Substep 7. The process described in substeps 1 through 6 is iterated for all J subsystems in the input data.

Help: None. This is an autonomous function of Product Four.

2.2 Production of principal comparison case.

Rationale: A principal comparison case is produced based solely on the comparisons and figures of merit resulting from the initial activation of the composite comparison engine.

User: This action is user independent.

Product Action: Creates a principal comparison case by selecting the comparison subsystem with the best figure of merit for each subsystem in the input data.

Help Available: None. This is an autonomous function of Product Four.

2.3 Identification of alternative comparison cases.

Rationale: The identification of alternative comparison cases provides helpful information to the user during the next function of Phase II, in which the user can accept or reject the principal comparison case.

User: This is the last of the autonomous functions of Phase II.

Product Action: Selects alternative comparison cases for each subsystem based upon the figures of merit associated with alternative comparisons. The figures of merit for each subsystem are selected in order to compose alternative comparison cases. The number of alternative comparison cases described by the most numerous subsystem in the comparison systems database is developed.

Help Available: None. This is an autonomous Product Four function.

Step 2.4 User review of principal comparison case.

Rationale: Before proceeding to the development of training characteristics data, the principal comparison case or some other comparison case must be accepted by the user.

Product Action: Presents the principal comparison case for user review. Figure 8 shows a notional screen presenting comparison case data.

User: Reviews the principal comparison case and decides whether or not to accept it.

Product Action: When the user selects and accepts the principal comparison case, product function proceeds to the identification of training and design characteristics (Phase III). When the principal comparison case is rejected, several options are presented to the user and the product responds accordingly. The

COMPARISON CASE DATA

For New System: AHX (Attack Helicopter)
 Composite identified as best fit to input data.

Composite Summary:

| <u>Subsystem</u> | <u>Comparison Case</u> | <u>Characteristics Match Data</u> (new system comparability in parentheses) |
|---------------------------------------|------------------------|--|
| Airframe | AH-1T | Weight (+ 5%) Crew Size (same) Range (+ 15%) Speed (+ 10%) |
| Armament | AH-64 | Missiles (same) Gun (same) |
| Target Acquisition and Designation | AH-64 | Direct View (same) LLLTV (+ 10% resol.) IIR (+ 25% resol.) Laser Des. (6 v 4 channel) |
| Engines | AH-1T | Number (same) SHP/Eng. (+ 30%) |
| Communications | AH-64 | UHF (same) VHF (same) HF (same) Crypto (same) |
| Navigation | AH-64 | VOR (same) NAVSTAR GPS (same) Inertial (new; no match) |
| ASE | AH-64 | IR Detect (+ 10% sens.) Laser detect (same) RF Detect (same) |
| Fuel | AH-64 | Type (same) Capacity (+ 8%) |

PAGE DOWN for more comparison information

Additional poorer-fit composites : 2

| | | | | | | |
|----------|---------|----------|-----------------------|-----------|--------|--------|
| Options: | PAGE-DN | NEXT-COM | <u><CHANGE></u> | CHG-INPUT | DO-TNG | ACCEPT |
| | PAGE-UP | CHK-PNT | SAVE-END | SAVE-DO | ABORT | HELP |
| | | PRINT-PG | PRINT-CM | | | |

Change the composite by substituting different subsystem(s)

Figure 8. Comparison case data.

options and corresponding product functions listed below are described in Steps 2.5 through 2.7:

- (1) Review the alternative comparison case candidates (Step 2.5).
- (2) Override Product selections with respect to any of the generated comparison cases (Step 2.6).
- (3) Modify input data and rerun comparison case identification (Step 2.7).

Help Available: Explanations of the options available and the consequences of selecting each option will be provided as necessary.

Default: The principal comparison case is accepted, as is (the first option).

Step 2.5 Review of alternative comparison cases and modification of the principal comparison case.

Rationale: The user may have information that indicates that the principal comparison case is not the best alternative upon which to base the identification of the training and design characteristics data. At this point the user may select an alternative composite case for adoption for the estimate.

Product Action: Presents list of alternative comparison cases generated by the comparison engine.

User: Selects one or more alternative comparison cases for review, and examines the data. The user can accept an alternative comparison case, or execute one of the other available options.

Product Action: When an alternative candidate case is selected, the Product utilizes the alternative for generation of the training characteristics estimate.

Help Available: Explanations of the available options and the implications of selecting each option will be provided as required.

Step 2.6 User override of Product Four comparison case selections.

Rationale: This option is available for the situation where the user has information that indicates that neither the principal comparison case nor the alternative comparison cases are suitable for the composite.

User: Overrides principal or alternative comparison case subsystem selections and modifies the comparison case at will.

Modification takes place by the user's specifying one or more alternative subsystems (from the comparison systems database) to be used in place of those identified by the comparison engine.

Product Action: Alters the comparison case to reflect the user's modifications.

Help Available: Information associated with applicable subsystems in the existing systems database, including information about their evaluation as alternatives for developing the comparison case, is provided as required.

Step 2.7 User modification of input data.

Rationale: At this point the user can select to revise the input data on which the generation of the comparison case is based.

Product Action: Returns the user to Phase I, where the user can revise the original input data. The Product queries the user as to the subsystem(s) and attribute(s) to be re-entered.

User: Enters the information in a manner similar to original data input.

Product Action (after user action): Saves the new version of the input data and returns Product function to activation of the comparison case identification engine. A new version code is added to the new version data for archival and retrieval purposes.

Help Available: All of the help that is available during Phase I is available during re-entry or modification of proposed system input.

Step 2.8 Data management.

Rationale: Users can elect to save or to delete any versions of the comparison case identification outputs or input data sets, to facilitate additional analyses or re-analyses based on modified input data.

User: Indicates the desire to delete a specific version of the composite comparison or data input.

Product Action: Automatically saves all versions of the input data and of the resulting principal comparisons cases and alternatives and assigns version numbers, unless directed by the user to delete (a) specific version(s) of the data.

Help Available: At any point previous versions of data can be reviewed. The accomplishment of this function is fairly

straightforward; additional user help is not expected to be required.

Default: All versions of comparison case identification output and data input are saved.

Phase III -- Training and Design Characteristics Generation and Modification

Overview

The flowchart in Figure 9 illustrates the functions performed in Phase III. After the user accepts a comparison case (either as generated or as modified by the user), the training characteristics and design identification engine is invoked. This engine retrieves the training and design characteristics information associated with each of the subsystems in the comparison case. This information is then conditioned by some adjustment factors (to be identified in the detailed design of Product Four), to produce the training and design characteristics for the proposed system. In addition, remediation and prescription data associated with the high drivers and design problems are identified during this Phase. Once again, the user has the opportunity to review, modify, and override the training and design characteristics and other data before accepting the training requirements projections. As with previous phases of Product operation, the user is able to alter input data or the comparison case, in order to explore alternative training consequences or conduct sensitivity analysis.

Detailed Functional Description

Step 3.1 Activation of training and design characteristics estimation engine.

Rationale: The engine is activated to generate the training projection, high driver, design, and remediation prescription data.

User: In order to activate the training and design characteristics estimation engine, the user accepts a comparison case.

Product Action: Retrieves training data associated with each subsystem included in the composite.

Help Available: This is an autonomous function of Product Four, user help is not expected to be required.

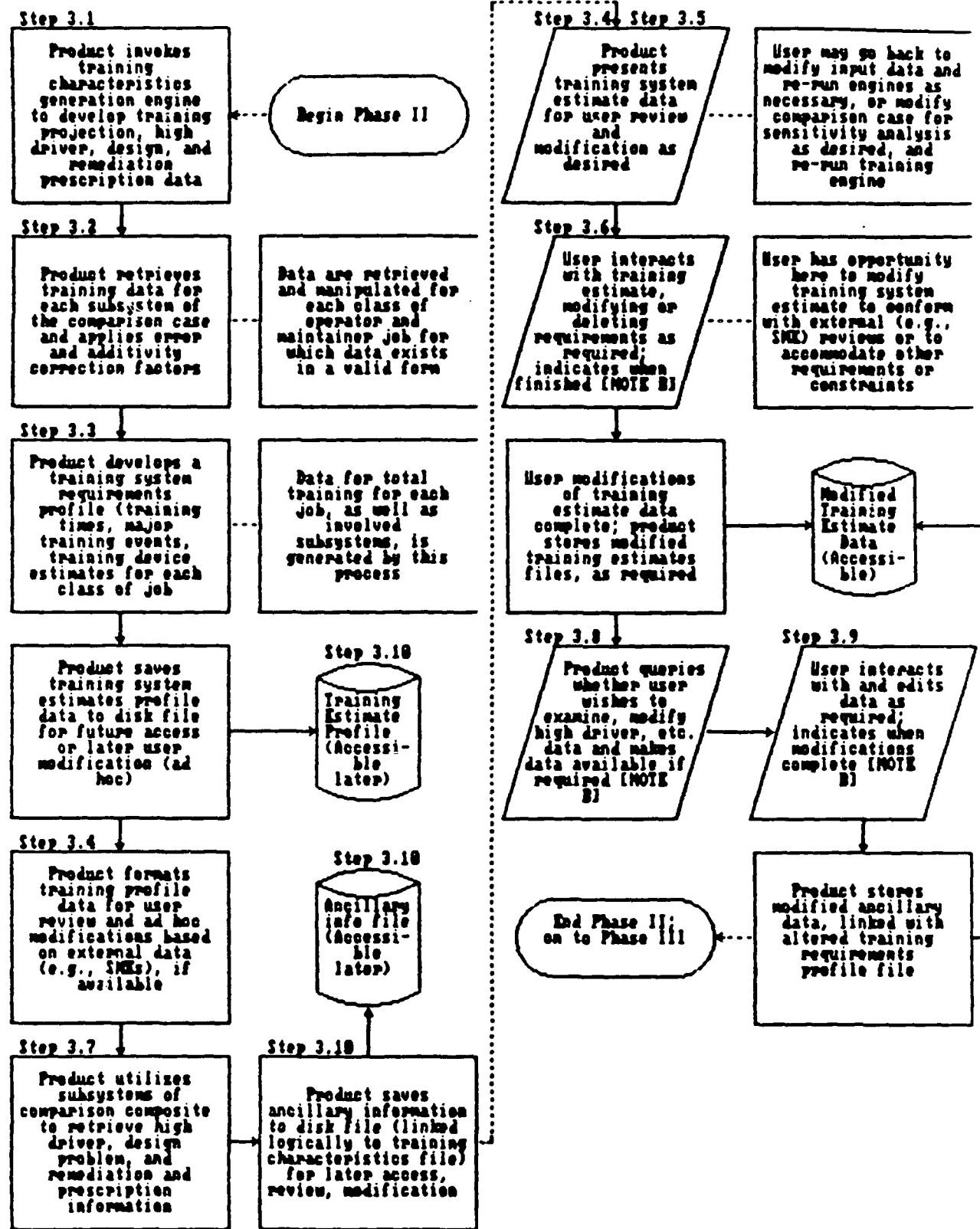


Figure 9. Phase III flowchart.

Step 3.2 Application of error and additivity factors to training data.

Rationale: This step allows for consideration of the range of error involved in this type of estimate and of times when the simple addition of training factors will give an unreasonable estimate of training requirements. This function is separate and independent of the user modification of the data that occurs at the end of Phase III.

User: It is expected that this function will be an autonomous Product action and will occur automatically upon activation of the training and design characteristics estimation engine.

NOTE: The overall process and specific data manipulations underlying the application of error and additivity factors have not yet been determined. The actual process will depend on findings of explorations of data properties in later Phases of this effort.

Help Available: The application of the error and additivity factors is expected to be an autonomous function, as such user help will not be required.

Step 3.3 Generation of training projections.

Rationale: The corrected subsystem training characteristics data are used to generate the training projections by subsystem and job that are part of the output of the Product.

User: This is an autonomous Product Four function.

Product: Develops and saves the profile that includes training times and training devices, listed by operator and maintainer job class and subsystem.

Help Available: User help is not required.

Step 3.4 User review of the training projections.

Rationale: The user is given an opportunity to modify the training projections prior to output, to suit cases where additional information may be available. This accommodates the application of constraints upon the training system that may be imposed as a part of the system requirements generation process.

*Product: Formats data for user review and presents formatted data.

User: Reviews the training projections and decides whether to accept or reject the training projections. A notional screen of data illustrating user review is shown in Figure 10.

TRAINING SYSTEM CHARACTERISTICS ESTIMATE DATA

For New System: AHX (Attack Helicopter)

Operator Training Summary

Page 1 of 12

Crew Position #1 (Pilot)

Initial Qualification Training

Comparison Cases: AH-1T, AH-64

| Course Description | Length | Hands-on | Academic | TDs | Other |
|--|--------|----------|----------|---------------|----------------|
| Initial Entry Rotary Wing - Common Core | 14 wks | 8 wks | 6 wks | 2B24 | Acft TH55 UH60 |
| Initial Entry Rotary Wing - Attack Track | 12 wks | 10 wks | 2 wks | 2B24 2Fxxx | Acft AHX UH60 |
| Unit Transformation Qualification | 13 wks | 13 wks | -- | 2Fxxx | Acft AHX |

Correction Factors Applied: None

PAGE DOWN for more training information

Options: PAGE-UP MODIFY ACCEPT CHG-COMP CHG-INPUT CHK-PNT
<PAGE-DN> PRINT HELP SAVE-END SAVE-DO ABORT

Display Next Page of Data

Figure 10. Training system characteristics estimate data.

Product Action: When the user accepts the training projection, the Product proceeds to the retrieval and presentation of the high driver, design factors, and remediation and prescription data. When the user rejects the training projection, the Product presents the following options that are described in Steps 3.5 and 3.6:

- (1) Modify original data input (Step 3.5).
- (2) Modify training projection (Step 3.6).

Steps 3.5 and 3.6 are not performed if the user accepts the training system characteristics data generated.

Help Available: User help will include descriptions of the options, reasons for selecting each option and the consequences of selecting each option.

Default: The training projections are accepted without user modifications.

Step 3.5 User modification of original data input.

Rationale: This option allows the user to perform sensitivity analyses to explore the impact on training system characteristics of different input data or defined comparison cases.

User: Indicates subsystem(s) of comparison case to be modified.

Product Action: Returns user to original data input.

Help Available: Any help available during the original data input will be provided here as required.

Step 3.6 User modification of training projection.

Rationale: The user may opt to directly modify the projections provided by the engine. This allows for cases where additional expertise or constraints can be applied to refine the estimates.

***Product Action:** Presents training profile and queries user as to the specific data to be modified.

User: Indicates the estimates to be modified and alters those estimates as desired. The user also has the option of documenting the rationale for these modifications.

Product: Creates and saves another version of the projections to reflect the user modifications.

Help Available: Prompts and queries will be provided as required to aid the user in accomplishing the modifications.

Step 3.7 Generation of high driver, design characteristics, and remediation and prescription information.

Rationale: This information is part of the final output of the Product.

User: This is an autonomous Product Four function.

Product Action: Retrieves and saves high driver and design characteristics associated with each subsystem in the composite and the corresponding remediation and prescription data.

Help Available: This function occurs without user interaction; user help will not be required.

Step 3.8 User review of the high driver, design characteristics, and remediation and prescription data.

Rationale: There may be cases when the user desires to modify these data.

*Product Action: Formats and presents the data for user review and modification.

User: Decides to accept or modify the data.

Product Action: Upon user acceptance of the data, the Product stores either the unmodified original version or both the original version and the user modified version. If user decides to accept the data generated originally, Step 3.9 is not performed.

Help Available: Help will include explanations of instances when user modification is desirable.

Default: The high driver, design characteristics, and remediation and prescription data are saved without user modification.

Step 3.9 User modification of the high driver, design characteristics, and remediation and prescription data.

Rationale: The user may elect to customize these data or to modify the data based upon additional information available.

*Product Action: Presents the data and queries user as to the specific data to be modified.

User: Selects the data to be modified and makes changes as desired. Indicates when no changes are to be made or when finished with changes.

Product: Creates and saves another version of the data to reflect the user modifications.

Help Available: Querries and prompts to aid in the modification process will be provided as required.

Step 3.10 Data management.

Rationale: Both the original output from the training and design characteristics identification engine and version resulting from user modifications may be helpful to the user or to future users.

User: Data management during Phase III is automatic; the user is not required to perform activities related to data management other than indicating data or files to be deleted.

Product Action: Automatically saves the original version of the training and design characteristics and other data, and any subsequent versions that result from user modifications or re-analysis of input data.

Help Available: Data management is an autonomous function of Product Four with the exception of deleting files; information related to the deletion of files including when and why will be provided as required.

Output

Overview

Once the user has made the desired changes to the data (if any), the data (and results of any modifications) are saved and can be output at will. Output data sets can be archived at will, for comparison in sensitivity analyses or as templates for future exercise of the Product. Outputs need not be generated at the end of each use of the Product. An output of any completed version of analyses can be called for at any time. An overview of the output process is provided by the flowcharts in Figure 11.

Detailed Functional Description

Step 0.1 User definition of desired output.

Rationale: Various output formats, as well as different versions of data to be output will be available.

Product Action: Querries user as to the format and version of data to be output.

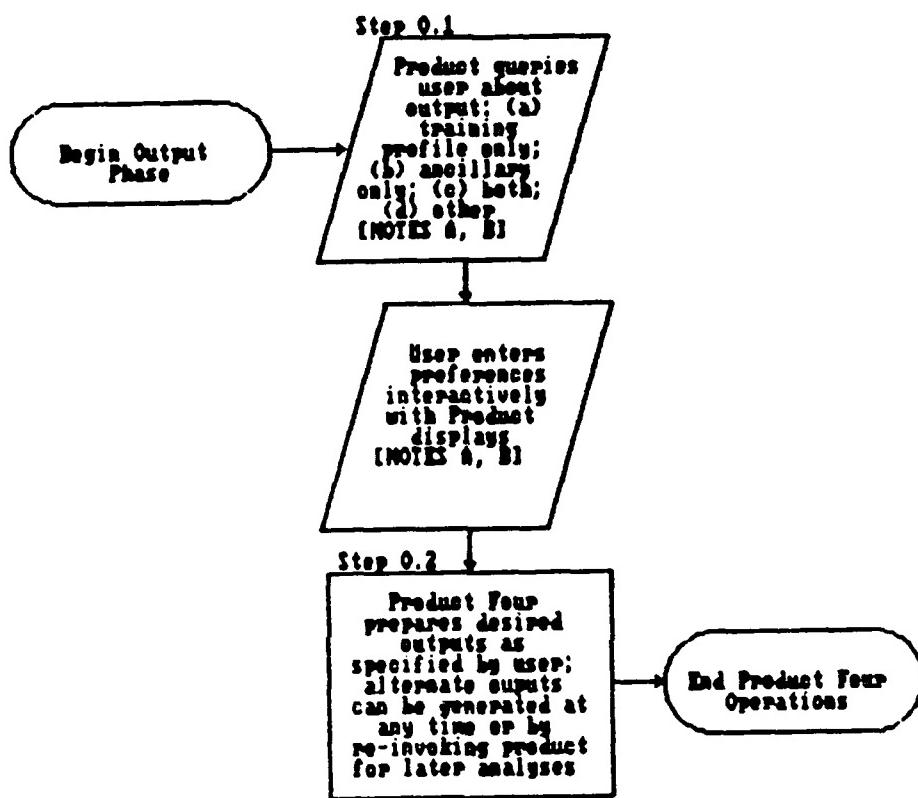


Figure 11. Output flowchart.

User: Indicates the specific information to be output.

Help Available: Help will include lists of the available versions of each information type and opportunity for review of that data.

Default: The latest user modified version of the training estimate and ancillary data are selected for output.

Step 0.2 Data Formatting and Output.

Rationale: The data will be formatted in a fashion determined to be useful by the Product Four designers.

User: Indicates that output is desired (if variable formats for output are identified by the Product Four designers, the user will select an applicable format).

Product: Formats and outputs data as indicated.

Default: A default format option will be defined by the Product Four designers.

This concludes the description of Product Four operation. The next section of this paper describes the data required for developing and operating Product Four, and where those data will be obtained.

SECTION FOUR

PRODUCT FOUR DATA REQUIREMENTS AND DATA SOURCES

Overview

This section of the concept paper discusses data requirements for Product Four operation and data sources from which information will be gathered to develop Product Four. This discussion is keyed to the first four of the five sequential steps of Product function, as discussed in the previous section. The final step, Output, requires no unique data. A subsection of this section is devoted to discussing data requirements for each of the steps requiring data. In each subsection, data requirements are discussed first. Then, data sources are addressed in detail. Note that significant amounts of the data required to develop Product Four will be elicited from SMEs. Approaches for effectively and efficiently eliciting these data are addressed in appropriate places in this section. Figure 12 presents an overview of data requirements and sources for the data needed to develop Product Four.

User Activation Data Requirements and Sources

Data Requirements

The first step of system operation, User Activation, requires the user to decide among three choices: (1) Develop a new training estimate for a new system; (2) Review and possibly refine one or more existing estimates already on file; or (3) Enter the embedded training function of Product Four. The only database required to support this phase is an audit file which archives all previous files formulated. This file is developed and maintained by the Product Four software system.

The audit file will allow a user to select one or more previously developed files. For each file selected, Product Four will reproduce the template of functional requirements originally given, identify the comparison case(s) which Product Four produced, and highlight any modifications which the prior user made to override the product's output. Additionally, Product Four will provide an audit of training characteristics, training high drivers, high driver-associated design factors, and remediation and prescription data provided for each file developed.

PRODUCT FOUR DATABASES AND DATA SOURCES

| Audit Filed Mission Area (by Product Four) | | Comparison System Database | Training Characteristics Database | "High Drivers," Design Problems Prescription Database | Standard HFE References |
|---|--------------------------------------|---------------------------------|---|--|-------------------------------|
| DATA REQUIREMENTS | Product One Output Plans (MAP) | SIC AWTB Database Data | NFPA NETDB Database (NFAS) | SIC AWTB Database POIs Data | WOLF Database Data |
| - ACTIVATION - | X | | | | |
| - User input concerning audit files to use | | | | | |
| - PHASE I - | | | | | |
| - Input Data | X | X | | | |
| - Data Models/Templates | | X | X | X | |
| - PHASE II - | | | | | |
| - Comparison Systems Data | | X | X | | |
| - PHASE III - | | | | | |
| - Training Characteristics Data | | | | X | X |
| - Training "High Drivers" Data | | | | X | X |
| - Design Problems Data | | | | X | X |
| - Remediation/Prescription Data | | | | X | X |

Figure 12. Product four databases and data sources.

Data Sources

The audit file will be dynamic in that it will grow as each user decides to save a training estimate. Each new file will be indexed according to the general class and subclass (e.g., aviation [attack]) of system which it defines. One issue for further study is determining how this growing database will be managed. It is possible that the number of training estimates on file could be so large that a user could be inundated with options. Some files may differ substantially in specific subsystems selected for the comparison case, whereas others may differ only in performance specifications of subsystem characteristics (input data). Product Four will be designed to provide a new user with a simple way to access existing audit files selectively.

If, in the User Activation phase, the user decides to obtain an entirely new estimate based on specifications for a new type of system, Product Four proceeds to Phase One, data model development.

Phase I -- Development of Data Model and Data Input

Data Requirements

Two data sets are required: user input data, and the comparison systems database. These are described below.

Input Data. The Product Four user inputs performance characteristics for the system for which the training estimate is desired. Performance characteristics are defined at the subsystem level, in terms of specific attributes of performance. The attributes will naturally differ from one type of subsystem to another, and will vary across systems of a given type.

Input data must contain the same type of information as is available for systems in the comparison systems database. Although some performance characteristics for new systems will be different than those of existing systems, the types and units of measure should be the same.

Our approach for Product Four requires input data and comparison systems be identical in units of measure. However, users will not be expected to be able to provide as exhaustive a description as is available for existing systems. Input data will, therefore, be entered according to a data model or template of critical performance criterion areas (comparability attributes). This data model will be derived from the form of data that reside in the comparison systems database. This

approach is critical to the ability of the Product to automate the identification of comparison cases to support training predictions.

The specific form of the input data can be identical to the output of Product One, as long as each performance criterion, represented as Product One output, can be isolated and assigned to appropriate data model subsystems. Product Four input data will be in the form of a functional profile of the desired system's characteristics.

A basic assumption of the ASA/SAIC approach is that any new system to be developed will fit the classification of Army systems by the following mission areas and proponent agencies.

| MISSION AREA | PROPOONENT |
|--|--|
| Close Combat (Heavy) | U.S. Army Armor Center, Fort Knox, Kentucky |
| Close Combat (Light) | U.S. Army Infantry Center, Fort Benning, Georgia |
| Aviation | U.S. Army Aviation Center, Fort Rucker, Alabama |
| Air Defense | U.S. Army Air Defense Center, Fort Bliss, Texas |
| Combat Support Engineering & Mine Warfare | U.S. Army Engineer Center, Fort Belvoir, Virginia |
| Combat Service Support | U.S. Army Logistics Center, Fort Lee, Virginia |
| Fire Support | U.S. Army Field Artillery Center, Fort Sill, Oklahoma |
| Nuclear, Biological, Chemical | U.S. Army Chemical School, Fort McClellan, Alabama |
| Command & Control | U.S. Army Combined Arms Center, Fort Leavenworth, Kansas |
| Communications | U.S. Army Signal Center, Fort Gordon, Georgia |
| Intelligence & Electronic Warfare | U.S. Army Intelligence Center, Fort Huachuca, Arizona |

This classification supports the organization of data by system class (essentially, the Branch identification) and subclass (type of system; e.g., Aviation--Attack helicopter, etc.).

Another basic assumption is that every Army system can be described in terms of an aggregation of subsystems with corresponding performance requirements associated with subsystem functions.

Comparison Systems Data. The second data requirement is the comparison systems database. The overall approach in Product Four is a template-matching task which, like any template matching task, is affordable only if it operates within a limited domain. If the domain is limited, as it is in the case of Army systems, template-matching can be extremely useful. The comparison systems database provides the domain from which existing systems are identified and corresponding subsystems are selected to form the composite comparison case on which the training estimate is based.

The comparison systems database will have three organizing levels of data elements: systems, subsystems, and subsystem attributes. Figure 13 illustrates the relationships and structure among these data elements. The systems level of the database will incorporate all major systems within the combat and combat support branches of the Army. Based on our projections, this should consist of no more than 165 unique systems.

Subsystem attributes are information upon which training comparisons between existing and new systems will be based. This means that based on similarities among subsystem attributes, training for existing systems is predictive for the new system. As such, defining the exact nature of these attributes is critical to the accurate matching of existing subsystems against desired subsystems.

The example in Figure 14 shows that for the target acquisition subsystem (of Stinger), the optical sight has a 1:1 magnification and that operator procedures are characterized as complex. ASA/SAIC will similarly catalogue for each subsystem of every system in the Existing System Database, the specific values (e.g. horsepower, range, channel capacity, sensitivity, resolution, etc.) of its attributes.

The number of subsystem attributes contained in the comparison systems database will be large, but not insurmountable within the scope of the effort. Our initial estimate of the total number of subsystems attributes in the database breaks out as follows:

| | |
|------------|---------------------------|
| 11 | System Classes (Branches) |
| x 6 | System Types per Class |
| x 2.5 | Systems per System Type |
| x 10 | Subsystems per System |
| <u>x 5</u> | Attributes per Subsystem |
| 8,250 | Total Attributes |

STRUCTURE FOR COMPARISON SYSTEMS DATABASE

(Shown as hierachial, may be associative or relational as developed)

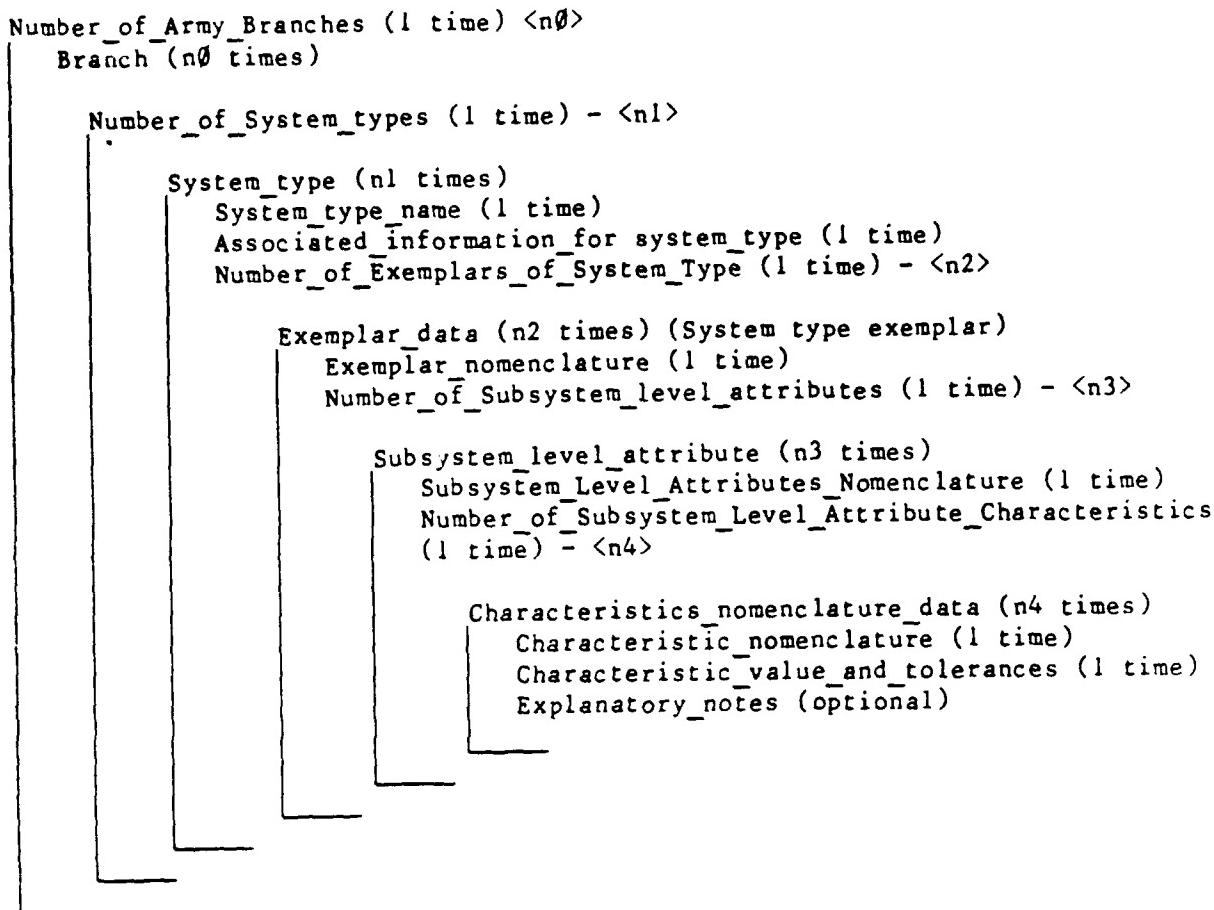


Figure 13. Candidate database structure (warnier notation) for the existing systems database and input data.

Example record contents:

System_type := Air Defense Artillery (Man Portable)

Exemplar_Nomenclature := Stinger (MXXX)

Subsystem_Level_Attribute := Target Acquisition

Characteristic_Nomenclature_1 := Optical Sight

Characteristic_Value := Unity Power

Characteristic_Nomenclature_2 := Operator Procedures

Characteristic_Value := Complex

Explanatory_note := <operator procedures complex
because set-up of launcher and sighting require many
steps to be remembered and performed in exact sequence>

Figure 14. An example data record for an entry in the existing systems database.

If one were to assume that it would take three weeks to obtain subsystem attributes for each of 165 system types (or 165 systems), this would add up to about a four person-year effort. This is likely a gross overestimate of required level of effort, because there are two Army databases which provide detailed information to the subsystem level for all fielded systems and systems in the Material Acquisition Process (MAP). These databases and methods for developing the comparison systems database are discussed below.

Sources of Data for the Comparison Systems Database

The comparison systems database is a key element to the success of Product Four. Its size will determine how long it will take the user to estimate the probable training for a new system. Therefore, the number of subsystems and attributes per subsystem must be kept at a minimum.

Three sources of information will be used in generating the Existing Systems Database:

1. the Sample Data Collection (SDC) database;
2. the Army-Wide Test & Evaluation Database (AWTEDB); and
3. SMEs.

The SDC database and the AWTEDB will be used as sources of system and subsystem performance characteristics for existing systems. The SDC database is developed by AMC's Materiel Readiness Support Activity (MRSA) and contains Reliability, Availability, and Maintainability (RAM) and some performance data on all major systems currently fielded. These data are provided at the subsystem level. For systems not currently fielded, but in the Materiel Acquisition Process, the AWTEDB provides both RAM and performance data on all systems tested.

Figure 15 shows a schematic of how we will develop data for the comparison systems database.

SDC Data. The first data source is the mandatory SDC program (AR 750 - 37) established by Deputy Chief of Staff for Logistics (DCSLOG). Discretionary SDC programs are established by equipment proponents when properly justified and approved by the DCSLOG. Mandatory and discretionary SDC requirements are identified after the awarding of a full scale development contract, and these are incorporated in the initial draft Materiel Fielding Plan (MFP). Major Command (MACOM) concurrence with the SDC concept defined in the MFP is formally conveyed through the signed Materiel Fielding Agreement (MFA).

There are three levels of SDC data collection. These are: user participant; proponent directed level one; and proponent directed level two. User participant data collection, in accordance with the approved Field Procedures Guide (FPG), requires unit personnel to record system

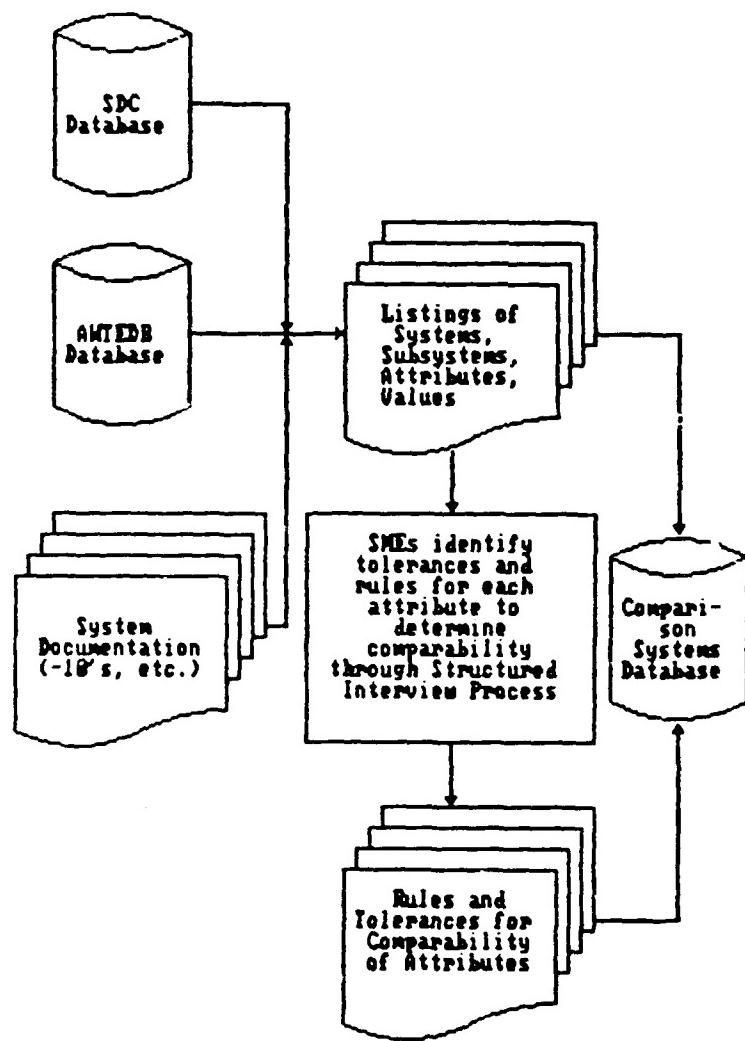


Figure 15. Developing the comparison systems database.

performance data on standard Army forms and forward these data to a source designated by the proponent activity. Proponent directed level one data collection, in accordance with the approved FPG, requires unit personnel to record the data on the standard, modified standard, or approved unique forms. On-site proponent agency members or representatives collect these data forms. They also obtain additional information, perform quality checks, and forward data to sources designated by the proponent activity. The third type of SDC data collection is proponent directed, level two. In accordance with the approved FPG, proponent agency members or representatives record data as events occur, collect SDC data forms completed by unit personnel, and conduct on-site observations and verbal inquiries. Data are assembled, edited, quality checked, and forwarded to the proponent activity. The level of detail in which the data are collected is determined by the importance of the system and cost constraints.

AWTEDB Data. The second data source for Existing System information is the AWTEDB. The AWTEDB has been developed to meet the needs of:

1. Department of the Army staff;
2. Army Materiel Command (AMC);
3. Training and Doctrine Command (TRADOC);
4. Operational Test & Evaluation Agency (OTEA);
5. their subordinate commands; and
6. other Army agencies

for collecting and disseminating in a timely manner test incident information on high-visibility systems being considered for possible acquisition by the Army. The data and information collected originates at:

1. Army installations where testing normally takes place;
2. Army agencies with responsibility for materiel acquisition; and
3. test facilities of government contractors.

The data are collected, stored, and disseminated at a central computer located at Aberdeen Proving Ground (APG), Maryland.

The AWTEDB contains system and subsystem performance attributes. These attributes are those listed in the Required Operational Capability (ROC) for each system. The ROC states concisely the minimum essential operational, RAM, and technical performance factors to be achieved by a new system. These ROC areas are evaluated in the technical testing of a hardware system. Data on testing results in

these areas is included in the AWTEDB. This database contains test incident data on all the systems and subsystems currently in the MAP.

SME Data. The third data source used in building the comparison systems database is SME opinion. SMEs provide the data used to develop the comparison rules that support the template matching process in developing the comparison case. SMEs may also provide performance parameters on systems and subsystems needed to develop a complete comparison systems database.

SMEs will be identified from among the personnel of the school directorates, school instructors and perhaps students attending various courses at the school. With some special coordination, it may be possible (if necessary) to have personnel in Forces Command units provide subject matter expertise.

Care must be taken when obtaining SME opinions. To facilitate the collection of SME opinions; ASA/SAIC will:

1. Tell the SMEs who we are, what our mission is, and how their input will be used.
2. Have the SMEs be interviewed independently. SMEs will not be allowed to discuss questions and answer as a group. Strong personalities, in a group, can often overwhelm issues of fact and influence individual responses.
3. Have an established reference for structuring SME opinion. For developing comparison rules and tolerances for the comparison systems database, this will require as a minimum that we present the SME with a list of subsystems, attributes, and units of measure for the attributes. SMEs will then be requested to identify rules that can be used to judge when a particular attribute is substantially similar to or different from the value for the existing subsystem and attribute in question. This may require substantial probing after the initial SME response for a comparison attribute. However, we are prepared to probe to the extent necessary in each case to obtain the rules needed to build Product Four.
4. Assure SMEs that their input will be used only for study purposes and that they will not be associated individually with their responses.
5. If the number of attributes for which rules are needed for a particular class of systems is large and a sufficient number of SMEs is available, divide the data gathering effort into sections and assign SMEs to specific sections.

The number of SMEs required for the development of the comparison systems database is dependent upon how much or how little can be obtained from the SDC and AWTEDB databases. The SDC database is promising because it is arranged in a hierarchical level of subsystems in a descending level of specificity. This provides the analyst and interviewer with a useful tool for structuring an SME interview. For example, the SDC listing for the AH-1 helicopter can be presented to an appropriate combat developer at Fort Rucker as a stimulus for obtaining subsystem performance criteria for the approximately ten subsystems listed.

SMEs to support development of the comparison systems database should be system-knowledgeable combat developers of at least the rank of E-6. SMEs are required to help define a limited set of subsystems (an average of 10 subsystems per system) and for each subsystem, identify subsystem attributes (an average of 5 per subsystems) which are particularly sensitive to the quality and degree of training provided. The following is a first order estimate of SMEs necessary to support development of the comparison systems database:

| | |
|-------------------------------|----------|
| Aviation | 20 |
| Air Defense | 6 |
| Armor | 14 |
| Nuclear, Biological, Chemical | 5 |
| Engineering | 7 |
| Field Artillery | 6 |
| Infantry | 11 |
| Intelligence | 6 |
| Signal | 4 |
| Quartermaster | 3 |
| C2 | <u>6</u> |
| TOTAL | 88 SMEs |

The SMEs will be used not only for developing the comparison systems database but also to assist in developing rules for driving the comparison process between new systems requirements and existing systems capabilities. The rules identified by SMEs for judging whether the attributes of subsystems are sufficiently similar to be considered the same are the rules that will be used by the comparison identification engine to develop comparison cases for training estimates development.

Phase II -- Developing the Comparison Case

Data Requirements

The template-matching engine allows automated identification of comparison cases, and includes rules for determining if input data

match the characteristics of subsystems in the comparison systems database. The minimum requirement for developing these rules is information on the most appropriate set of dimensions on which the performance of given subsystems should be compared to input data, and the criteria, or tolerances which should apply in making such judgments. As discussed above, these rules are derived from SME judgments, and capture those judgments in a knowledge base for re-use. The rules are contained in the comparison systems database, associated with every comparison attribute for every subsystem of every system in the database.

Data Sources

The source of the comparison rules will be the personnel who serve as SMEs for Product Four database development. These SMEs can be the same 88 SMEs used to identify subsystem attributes for the comparison systems database. The SMEs must be (in the aggregate) knowledgeable about all attributes of the subsystems of each system to be included in the database. We estimate it will take two days per SME (176 SME days) to gather data for developing the comparison systems database.

Our intention is to gather these data through structured interviews with SMEs at the proponent schools. An interview protocol will be developed and tested with the assistance of several SMEs, focusing on some sample systems and subsystems. Testing (in Task 2 of this effort) will enable us to discover the most fruitful ways to elicit SME opinion about the comparison rules to be developed. Once the interview protocol and techniques have been debugged, the interviews will proceed with SMEs at each of the proponent schools. We anticipate that the development of these data and the construction of the comparison case identification engine will be the most challenging aspects of developing Product Four.

Once the comparison rules (criteria, ranges, values, or tolerances for comparison) have been gathered, they will be used to implement the comparison systems database.

Phase III--Developing the Training Estimate, High Driver, Design Characteristics, and Remediation and Prescription Data

We will develop two somewhat distinct, but closely related, sets of data to support development and presentation of the training characteristics estimate and the training "high drivers," design problems, and remediation and prescription outputs of Product Four. Since these data will come from diverse sources, the training characteristics database requirements are discussed separately from the "high drivers," etc., data in this subsection.

Training Characteristics Data

Data Requirements. Training characteristics data are needed as part of the Product Four resident databases to support estimates of probable training characteristics for the new system. Data will be provided for each system and subsystem represented in the comparison systems database. This will allow training data coverage for any combination of existing subsystems which are used to define composite comparison cases. The data elements required to compose the training characteristics database (for each system in the database) are as follows:

1. Operator training time, by subsystem, for each class of operator job associated with the system;
2. Maintainer training time, by subsystem, for each class of maintainer job associated with the system;
3. Breakdowns of the two elements above, in terms of hands-on versus academic training time; and
4. Types and numbers of training devices (TDs) associated with training for each subsystem of the system, and the system at large.

Figure 16 shows a scheme for the level of detail of data to be collected for each system in the comparison systems database. This figure shows requirements for data broken out in three categories: operators versus maintainers; subsystems; and jobs. Although data may not fall out neatly among these categories, the composite-building nature of the Product Four approach will require separate data for each subsystem, and for operator versus maintainer functions. It is also recognized that training time for the total system will almost always be less than the sum of composite subsystem training times. This means that a correction factor must be considered when estimating total training time for the entire system, when composite comparison cases are used. The following subsection describes the sources from which the data elements will be obtained. Figure 17 is a schematic showing how we will develop training characteristics data.

Data Sources. The training characteristics database is an extension of the comparison systems database. For every subsystem in the comparison systems database, there will be training characteristics data identified for all operator and maintainer jobs related to the subsystem. As each subsystem of the comparison case is identified in Phase II, a new building block is correspondingly added to the training projection. The rest of this section addresses how training data will be obtained for each subsystem in the comparison systems database.

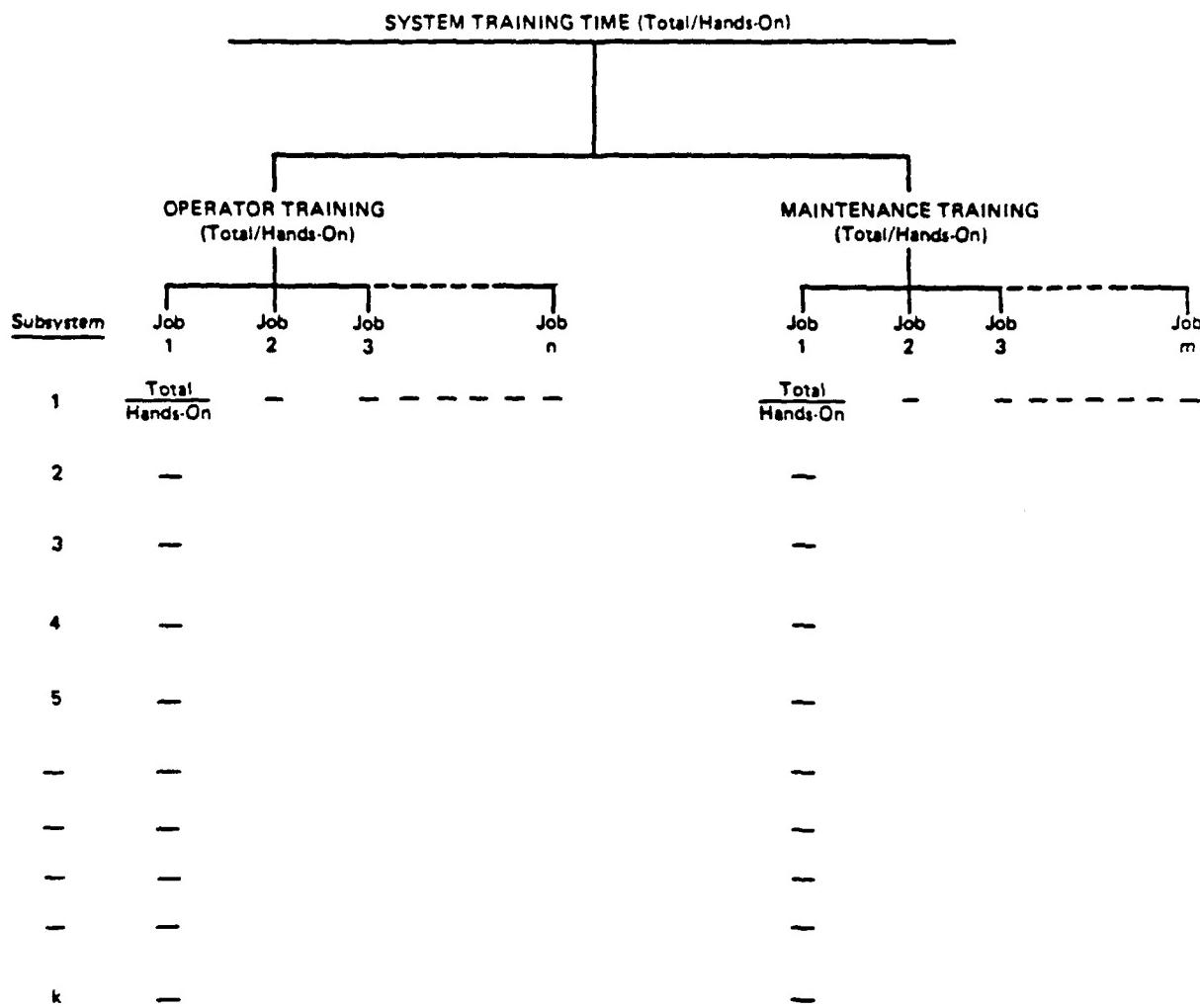


Figure 16. Schematic of training system data to be incorporated in product four training characteristics database (for one system).

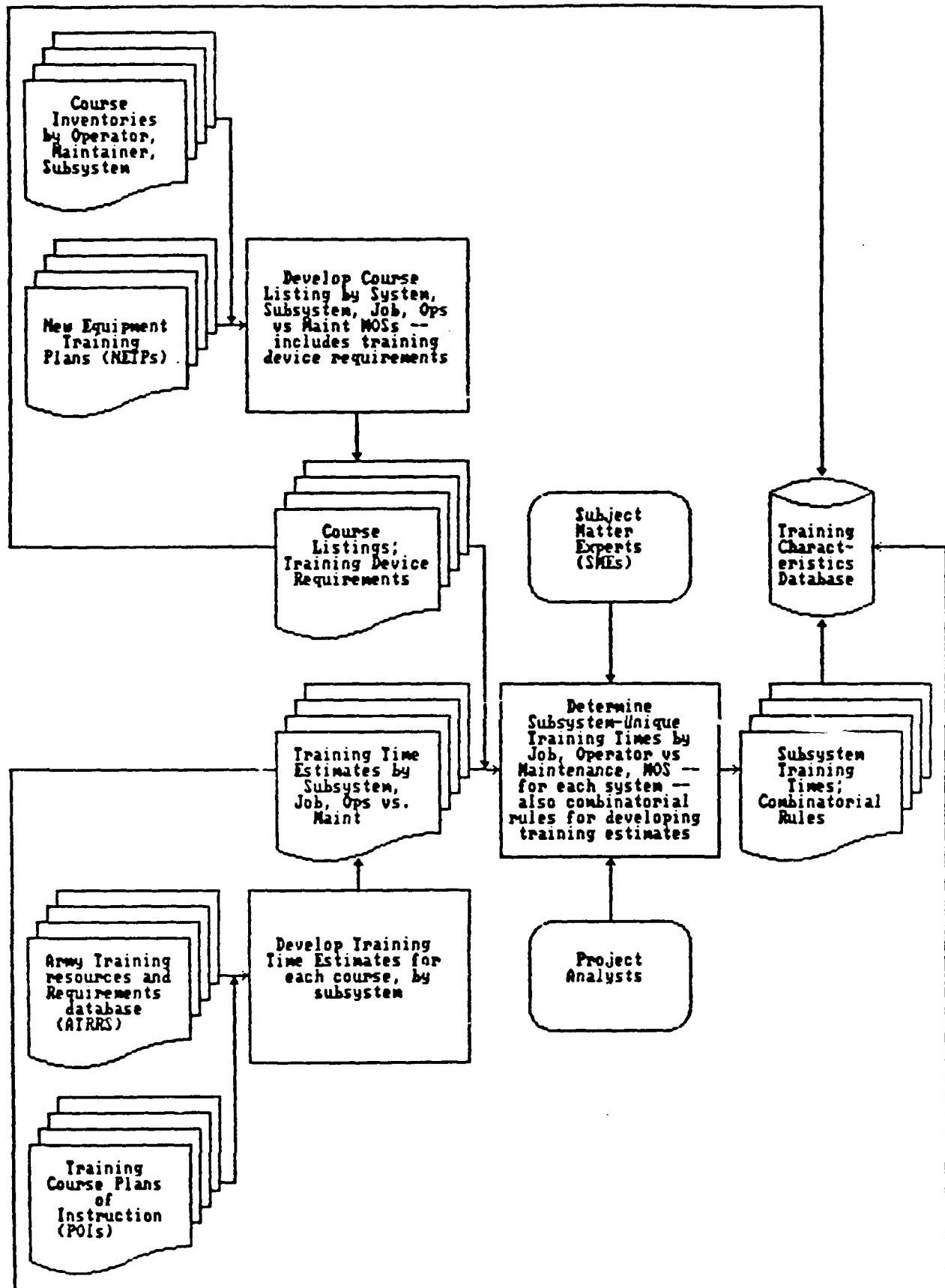


Figure 17. Developing the training characteristics database.

After an intensive search of existing databases and information systems, we have concluded that there is no single, comprehensive data source that associates training characteristics with each subsystem of all Army systems. Such an association is the heart of Product Four; i.e., relating training to a composite of subsystems which have never before been combined into the same system. Although HARDMAN experts who must also deal with composite systems have been faced with the same challenge, no attempt has yet been made to predict composite system training based on an additive rule which considers characteristics implied by each subsystem. Instead, HARDMAN experts abandon the composite when required to project training, and make projections on the basis of characteristics of the single closest fitting existing system.

There are four primary sources of data for the training characteristics database. These are: SMEs; New Equipment Training Plans (NETPs); Plans of Instruction (POIs) for existing training; and the Army Training Requirements and Resource System (ATRRS). These data sources overlap to a certain extent, and must be further investigated during the next Task of the effort to determine the extent of the overlap and finalize data gathering approaches. However, the nature of the data suggest two potential methods for data collection. We propose to evaluate the costs and benefits of each approach in a trade study to be conducted in Task 2 of this effort. The following paragraphs describe each method.

The first data source is SMEs. Using SMEs is labor intensive and involves a significant number of SMEs from the schools and from Project Manager for Training Devices (PM TRADE) (for training device data). The steps in the use of SMEs to determine training times for a subsystem are summarized as follows.

1. Identify all courses which relate to training operator and maintenance skills for each existing system in the comparison systems database. (Data sources: training course inventories [from schools]; New Equipment Training Plans)
2. Tabulate training times for each course. (Data sources: POIs, ATRRS)
3. Interview school instructor and PM TRADE SMEs and, for each subsystem within the area of expertise of the SME, determine how many hours of training time would be required if only that unique subsystem had to be learned, and identify the breakouts between hands-on and academic training involved.

Data to support Step 1 above will be obtained from DA Forms 5316, (NETPs), and from school listings of courses. The Deputy Chief of Staff of the Army for Operations (DCSOPS), the Army proponent agency for NETP's, maintains a database which identifies all jobs and courses associated with any system fielded within the past seven years, and any system currently in the acquisition process.

Step 2 data will be obtained from the ATRRS database, which contains an extensive database on training characteristics associated with all courses taught by or for Army personnel.

The SME interview process described as Step 3 above will require SMEs to think about training from a perspective which is foreign to the way they do business. This is particularly true of maintenance courses where skills must be taught across a number of subsystems of various systems. Unlike RAM databases in the logistics communities where performance data are collected at the component and sub-component levels, training databases contain data at the levels of functional areas, courses and jobs.

Because the above method is foreign to SMEs, the protocol for SME interviews must be sensitive to SME uneasiness. It will be designed to educate the SME with regard to the purpose of the interview, and should encourage SMEs to help make it a better process. The protocol will be developed with the help of several SMEs and will undergo iterations as required.

Current estimates of the number of SMEs needed to assist in the development of the training characteristics database is as follows:

| | | |
|------------|---|------------------------|
| PM TRADE | - | 5 SME days |
| 11 Schools | - | 3 SME days per school. |

This is a total of 38 SME days from all sources. Next, we discuss an alternative, less SME-intensive, method of obtain training characteristics that we will explore in Task 2.

An alternate data source for obtaining training characteristics at the subsystem level is the partial replacement of Step 3, SME interviews, with the database supporting the NETPs. This database, the Army Modernization Training Automation System (AMTAS), is an extremely powerful tool because it is the only identified source of information which isolates training data at the subsystem level. It also represents the most current impact of high-technology systems on training requirements and thus increases the probability of providing "best fit" projections to meet new system performance criteria input by the Product Four user. It is also less prone to the compounding of error which occurs every time the artificially-derived training estimates (based on SME interviews) are added up across subsystems.

The potentially negative aspect of using NETPs as a data source involves comprehensiveness. As of now, it is uncertain how many of the comparison systems database subsystems are represented in the AMTAS database. To understand this issue better, a brief discussion of the AMTAS is required.

The NETP (residing in the AMTAS) is required before any new system or product improvement (PIP) is fielded. This plan must address, at a detailed level, all new training required by the new or modified systems. The training estimate given in the NETP identifies the specific increment or delta in both operator and maintainer training which the modified or new system requires. The utility of the NETP in Product Improvement data will be most useful to Product Four. For example, if a Product Improvement involves only the upgrading of a tank turret, the NETP will only address the impact of the new tank turret in terms of increased training time, etc. Therefore, the AMTAS database will only yield subsystem-specific training impacts if there was only one subsystem involved in a product improvement. With over 1,000 NETP's represented in this growing, archival database, it is likely that Product Improvements will provide significant amounts of training related data at the subsystem or near-subsystem level.

NETPs are developed, coordinated, published, and distributed by the materiel developer for each item of significantly modified equipment for which training is required (AR 350 - 35). This includes ancillary items such as training devices. A NETP should include, as applicable, training for staff planners, developmental and operational test personnel, trainers, supporters, and users. The NETP covers all training aspects of the equipment from procurement or development and testing through production and fielding. NETP considers the following: similarity to previously fielded systems; current state of the training base to support the new equipment; technical complexity of the new equipment; fielding rate; effects on unit readiness; overall training strategy for the new equipment; planned density of the new equipment, available trainers in the units to increase training; and quality of personnel to be trained; available training devices, ranges, facilities, and training materials; environment where new equipment is to be fielded; funding; ammunition to support NET; and sustainment training following fielding.

Data pertinent to the development of Product Four contained in the NETP include the system and subsystem, the Military Occupational Specialty (MOS) associated with that system and subsystem, and the training time affecting each MOS. Once the MOS decision is made, the hours needed to train that MOS on that new system and subsystem is determined. Those affected MOSs are listed and can be determined in reviewing the plan in two ways. First, the training base established (tbe) relates to a particular MOS the exact number of training hours associated with the new equipment to bring that particular MOS up to speed. Second, if hours are listed under the column "additional skill identifier (ASI)," then that MOS requires the indicated hours of training to bring soldiers up to speed on that new piece of equipment. If there is a blank next to a MOS, then no additional hours are needed to train them on the new piece of equipment. Both grade (10, 20) and level of maintenance [organizational maintenance (OM), direct support (DS), and general support (GS)] can be determined by reviewing this plan.

Another potential source of data for the training characteristics database is the ATRRS. This system reports the availability of training resources. These resources include instructor contact hours (ICH), cost, and support equipment. ODCS PER, Force Management Division, is the proponent of ATRRS. U.S. Army Information Systems Command's (USAISC-P) computer in the Pentagon is host to the ATRRS system. This information system draws information from and provides information to four levels of command: Department of the Army; Military Personnel Center and its Reserve Component counterparts; Army school systems; and Army's schools and training centers (AR 350 - 10).

A valuable trade study that we intend to conduct in Task 2 is to select a representative existing system and to implement both of the above methods for identifying training characteristics of the its subsystems. This process could be repeated on other systems, and a trend might be ascertained with regard to the reliability and validity of the alternative methods. Obviously, if both proved to be of equal value, the less SME-intensive method (i.e., the NETP method) will be less costly and more valid, and therefore, the chosen method.

Training "High Drivers," Design Characteristics, and Remediation and Prescription Data

Data Requirements. Three data requirements have been identified: training "high drivers," design characteristics related to high drivers, and remediation and prescription data.

Training high drivers are skills, knowledge, and abilities which require the most training to ensure soldier competence. They are indicated by a high percentage of time needed for training and by subjective factors of difficulty provided by experts who provide the training. These "high drivers" will be identified and catalogued according to systems, subsystems, operator or maintainers, and specific jobs.

Design characteristics related to high drivers is the second data requirement. These are known, correctable flaws in the design of the SSIs of existing systems which cause increases in training. The design characteristics data will be restricted to factors which are correctable within the state-of-the-art of SSI design.

Remediation and prescription data is the third requirement. These data are provided as principles (associated with specific training "high drivers" and associated design characteristics) to guide system designers in their choices during design, to minimize training requirements.

The key to ensuring the utility of this database is to provide the correct level of guidance. Too many guidelines may unnecessarily

constrain the designer or be so specific as to increase the probability of inaccuracy, and thus challenge the credibility of the system (this Product) used to develop the guidance. Too few guidelines will result in a high repetition of over-general statements across subsystems, which will quickly be ignored by the user and designer. The guidelines, therefore, must be responsive to the actual problems that exist with systems and subsystems in the comparison systems database.

We will develop these data within two specific constraints:

1. The work to develop the training characteristics estimation capability of Product Four will not be compromised in any way by providing these data; and
2. All output of this feature will relate directly to training aspects of SSI design which have been shown to be problem areas for existing systems. This means that Product Four will not be a general interface design guideline aid.

Note that we do not expect that there will necessarily be training "high driver" or design problem issues with each subsystem of every system to be explored for Product Four. In fact, it is probable that only a relatively small percentage of systems will have such problems. However, we feel it is very important to provide designers with a means of reducing the training impact of design decisions. Thus, we intend to pursue the development of this (not strictly required) component of Product Four. Figure 18 summarizes our approach to developing these data for Product Four.

Data Sources. Data sources for critical incidents which suggest design problems and training "high drivers" are: the SDC database, the AWTEDB, and the Work Order Logistic File (WOLF). The databases are intended to be used as sources of critical incidents, which will then be validated and expanded by SMEs. The databases are described below. Data sources for remedial design guidelines are standard human factors references.

The SDC program (AR 750 - 37) was described earlier. The SDC database is arranged in a hierarchical level of subsystems in a descending level of specificity. Data can be retrieved at any level within this hierarchy. This database is used in this Phase of Product Four because it includes failure incidents. Data on the number of incidents of equipment failure is accessed at the subsystem level. This number is an aggregate of all incidents which have occurred at or below the accessed level. The assumption is that hardware failures are frequently due to inadequate training or poor human factors engineering. Hardware which can be easily operated and maintained by the soldier does not induce errors.

Operator and maintainer induced incidents relating to subsystem failure can be accessed by code; e.g., #979 if incident was caused by maintainer and #437 if the incident was cause by an operator. These induced errors can be used to solicit SME opinion to

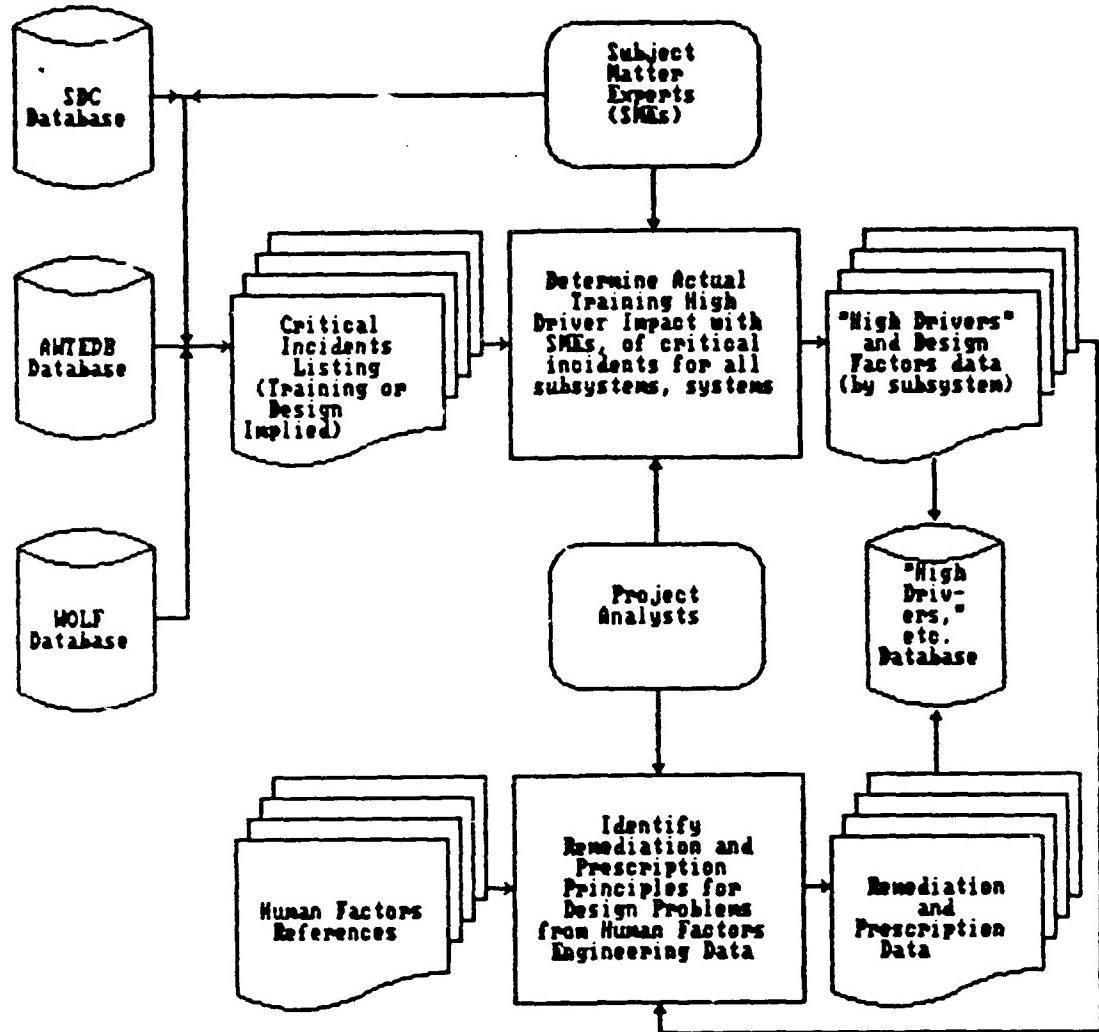


Figure 18. Developing the training "high drivers," design problems, and remediation or prescription database.

determine if the error could be attributed to training or design factors.

The AWTEDB was described earlier, and will be useful for developing training "high driver" and design factors data to support this element of Product Four.

The largest source of data in the AWTEDB comes from technical testing (TT) Test Incident Reports (TIR). Some operational testing (OT) TIRs coming from OTEA and others submitted by TRADOC and its test agencies are also part of this database. All TIRs are standardized across users. The basic requirement is that all originators of data and all automated systems be capable of transmitting TIRs electronically over the MILNET.

The second-most high-volume report in the AWTEDB is the Corrective Action Report (CAR). CARs are originated by Army project managers and developing agencies, and are sent to the central computer, either in hard copy or electronically, with the latter preferred. Once in the data base, CARs are interfaced with the TIR summaries to which they pertain, and the TIRs which have been deemed to have been corrected by the CARs are closed out.

The AWTEDB data useful to Product Four will be limited to a subset of the data contained on the TIRs. This subset will be those subsystem test incidents in which operator or maintainer performance errors occurred. These types of errors are often attributed to a lack of sufficient training or poor human factors engineering. These are called induced errors. The CARs pertinent to these types of errors will also be examined to determine the type of corrective action taken, if any.

The WOLF database provides maintenance data at the general and direct support levels (GS/DS). The maintenance data include the following: mean downtime, mean time to repair, and man-hour costs by MOS. The WOLF provides these maintenance data for the entire life cycle of selected items of each unit. Incidents of equipment failure due to operator or maintainer error can be tracked over a longer period of time than SDC data. This data source is useful for Product Four if system comparability needs to access systems not currently held on the limited basis as in the Army-Wide Test and Evaluation Database or the SDC Database.

The items chosen for inclusion in this database are listed in AR 220 - 1 (Unit Status Reporting). Items contained within this regulation are considered critical to Army unit function. Without these items the unit would be unable to perform its mission. The WOLF provides a broad picture of what is happening to these end items in DS/GS maintenance units based on a monthly volume of about 20,000 work orders. This system became operational in May, 1985. The most current 12 month data is kept. Each month the oldest month drops out as the newest month is added on. The WOLF provides incident data from which to glean training high drivers.

Product Four will make use of the comprehensive and detailed lessons learned available in the several Army databases discussed above to develop data to make up the training "high drivers" and design factors database. The key to this approach is the use of Army documented incidents as discussion items with training developer SMEs. For those subsystems of the composite system which have been designated as critical in prior tests, we will present all reports identifying human-induced failures to SMEs for evaluation.

The first step in SME interviews will be to show each SME the list of incidents for those subsystems pertinent to the SME's area of expertise. The SME will be asked to comment on the validity of these reports based on the SME's own experiences. Each SME will then be asked if additions to the list of critical incidents should be made for each subsystem.

When a complete list of problem areas is finalized, the SMEs will be asked if the quality or amount of training contributed to the problem, or whether engineering design was primarily at fault. The interviewer will then attempt to identify ways to either redesign the system or improve the training approach. All information elicited in SME interviews will be recorded in detail to support database development.

After the training "high drivers" and design problems information is elicited from the SMEs during interviews, the data will be recorded in the database structures of Product Four, associated with specific subsystems of systems in the comparison systems database. Where we are able to identify effective and straightforward SSI- design remediation or prescription data, these will be added to the records associated with the other data for each subsystem, to facilitate generation of outputs.

SECTION FIVE

TIME REQUIRED TO USE PRODUCT FOUR

We currently estimate that the Product can be exercised through one iteration in about four to six hours of clock time. This assumes that the user does not radically alter the input data model. It also assumes that the user does not conduct extensive explorations of the intermediate Product outputs (comparison case and training profile), or perform sensitivity analyses. Radically modifying the input data model may add several hours, perhaps a day, to the time required to use Product Four. This might be required if a new type of subsystem must be added to the data model, or if the attributes for many of the subsystems for developing the estimate must be changed.

The user can extend the time required to use Product Four by closely scrutinizing the intermediate products produced in operating Product Four and modifying them in various ways. We are uncertain how much time this might involve, but it could amount to between hours and days, depending on the inclinations of the user.

The user can also extend the time taken to develop a training characteristics estimate by performing sensitivity analyses. We expect that each iteration of Product Four operations in a sensitivity analysis could require from one to as much as three hours, depending on how much of the input data or the comparison case the user chooses to modify. For a sensitivity analysis involving four or five alternatives, perhaps one day would be required. The amount of time will go up more or less linearly with the number of alternatives the user chooses to explore.

The time required to gather and compose input data for using Product Four is unknown at this point. If Product One has been exercised (and if it produces the level of detail of system performance characteristics that we expect), the user will simply have to gain access to that data. We do not think this will be the typical case, however. It is more likely that much less detailed data (e.g., from a Mission Area Development Plan [MADP] or similar documents) will be available. In this case, either the user will have to rely on defaults from the Product Four existing systems database, or will have to access SMEs to augment the available data. If defaults are relied on, little time will be required. But, if SMEs must be consulted for performance characteristics estimates, much more time could be required. There is presently no way to estimate the amount of time users may need to get SME inputs for the input data.

SECTION SIX

DEVELOPING PRODUCT FOUR

Product Four will be developed in two stages, corresponding to the remaining two Tasks of the overall effort. The following discussion details the activities that we will perform in each of the two tasks to ensure a completely functional Product Four at the end of the contract period.

Stage 1 -- Design Specification Development

In Task 2, we will concentrate on developing detailed design specifications for the Product. The preparation of the design specification will involve consideration of exactly how to implement the Product, as well as development of specific data types, algorithms, and processes to be included. This constitutes the detail design of software and databases to implement the Product concept. We intend to adopt a software design approach, as well as allied documentation requirements, for development of the design specification. We anticipate the ultimate specification will be formatted as a type B5 (per MIL-STD-490) computer program development specification, accompanied by additional highly complete information describing training and interface characteristics.

The specification development process will begin by identifying all data elements required for effective operation of the Product, in exhaustive detail. Databases will then be designed with record and element structures implemented to efficiently support the execution of all software and user interface processes involved in Product operation. Data specifications will be developed (and documented per Warnier methods) prior to any processing design, so that an efficient implementation and test approach can be adopted. A sizing effort for total database structures (above and beyond what has been done to date) will also be conducted, in order to enable estimates of hardware support requirements for Product Four.

Next, the User-System Interface (USI) for the Product will be specified, along with development of the embedded training approach for product familiarization and support. We currently anticipate using menu-driven interface protocols to the extent that is possible, in order to develop a flexible and easily modifiable, but efficient mode of interaction for product users. A menu interface structure is extremely efficient from a learning to-use standpoint, and also is relatively simple to implement. Embedded "helps" for all functions and

interactive modes of the system will be designed into the USI. An embedded training mode, separate from normal system operations, will also be included to facilitate the ability of first-time users of the Product to quickly "come up to speed" and be able to develop training characteristics estimates quickly.

Design of outputs will be the next step in the development of the functional specification. We presently have an excellent idea of the information which will be developed by the Product at both intermediate stages of the estimation process and as final results, as discussed in Section Two of this paper. We will structure the information for output at each stage such that it presents the level of detail needed by each class of user, including the specific information on which the user must act, in a clear, concise, usable form. All data elements will be explicitly labeled, and the principles set forth by Smith and Mosier (1984) will be adhered to in the design of both the USI and output formats.

The next activity will be a top-down functional decomposition of the required processes of Product operation, to develop an overall modular design for software and procedures which will be part of the Product. We anticipate limiting the decomposition at this point to complete definition of the major processes of Product operation, with the operational details left for Task Three development.

Once the high-level operational modules of the system are described through the hierachial decomposition process, an Input-Process-Output (IPO) analysis will be conducted for each modular element of the system. This analysis will identify, in detail, the input requirements of each module, the processing which will take place in the implemented module, and the outputs of the module. Inputs and outputs which are operator-provided will be explicitly referenced to USI and output formats, as necessary. Internal process Input/Output (I/O) elements will be referenced to specific database elements. Processes will be described in the maximum detail possible, and documented in Chapin chart format for consistency and to implement an audit trail for later actual development of the product.

After detail development of the design specification is complete, we will prepare an overall summary of the design to support ARI's review. This summary will include data security considerations (especially if remote access is to be utilized), and will discuss in detail how institutional acceptance of the product will be gained. This latter point will be an expansion of the approach to institutionalization of the Product presented in Section Nine of this paper.

The final activities in this phase will be exhaustively document the results of the design specification development effort. The design specifications will be documented such that the following critical elements are presented clearly and concisely in the basic specification format:

1. Required data inputs for the Product as a whole and for each functional element, the location of the data, and how data will be accessed in developing the Product in the next stage of the effort.
2. The components of the Product (in terms of hardware and software to be included), how each will be obtained, and how they will interact in the ultimate Product.
3. Processes by which the Product will produce its outputs (the detailed B5 specification material).
4. Detailed description of Product outputs, as defined in the analyses discussed above. Both intermediate products and final products will be described exhaustively in terms of content, format, and access.
5. Computer file security assurance measures to be incorporated in the detailed development of the Product.
6. Means to be taken to insure organizational acceptance of outputs of the Product.
7. A detailed schedule and estimate of costs for Product development.

Stage 2 -- Product Development

In the second stage of the effort, conducted in Task 3, Product Four will be developed, debugged, and tested with realistic estimation problems. Also, iterative reviews with users will take place, to identify issues or problems to be resolved (in product usability, USI, or product content and format). The following activities will take place during the development phase.

First, we will identify the hardware needed for Product Four implementation, and access the needed hardware resources. We do not expect that large scale computational resources will be required to implement this product. We anticipate that a machine on the close order of an IBM PC/AT (or compatible machine) will be adequate to support the software and data requirements for this Product. Since this type of personal computer resource has become the second-generation PC standard for DoD at the present time, there is a high likelihood that such machines will be available to the user communities. We do not anticipate that hardware compatibility will be a problem.

We propose to purchase such a machine for use in developing the Product; this machine will of course later revert to the Army for use

by the Product's users. At the same time, suitable software will be purchased and installed on the target machine, including operating system, utility programs, and language compilers.

Next, we will undertake detailed software design. The top-level design produced in specification development will be continued until software is defined down to the unit function level. A development plan for the software will then be prepared and implemented to support comprehensive management of the software development process.

Next, we will develop and debug the software. We expect that a minimum of two iterations of development, testing, and debugging will take place. The first iteration will occur within the project team, and will concentrate solely on the development of valid, well-documented software which functionally executes the processes we specify in the system design. This stage will culminate with comprehensive user tests of the software (using test databases), to identify problems with the USI or with outputs. The second iteration will concentrate on optimizing the USI and output characteristics, and on testing the functionality of the Product against successively more comprehensive databases. In this process, we will attempt to exercise all possible contingencies. We will evaluate the consistent functionality of the Product and the usability of outputs in the wide range of situations likely in real-world application of the Product.

Concurrent with the development and testing of the software for Product Four, we will develop the data required for the Product's databases. We will conduct the data development approaches discussed in Section Four of this paper to develop each of the major databases in detail. As the data are gathered, they will be formatted according to our database design, and incrementally added to the master database files. All second-phase user and function tests of the Product will be conducted against the master database.

Next, we will develop and implement the embedded training component of Product Four. Although we here call this out as a separate activity, development of embedded training is most likely to occur in parallel with software development and testing. The embedded training component will be iteratively refined along with the software, to ensure that the training required by users is in fact present in the ultimate system.

SECTION SEVEN

PRODUCT FOUR USER TRAINING

The characteristics of the users we have identified for Product Four suggest that users will not be knowledgeable in the techniques that underlie Product Four functioning. Further, it is expected that users will know very little about database management, software, or computer use. Since we will be unable to establish a training element for Product Four users (by restriction in the contract SOW), the Product will have to provide all training for its users.

We propose to build into the software and databases of Product Four two components that will enable users to learn and use the capabilities of Product Four. The first is a comprehensive ET capability. The second is a context-sensitive Help and Explanation capability. We anticipate that the two components will share many data elements and software routines, since their purposes and functions are basically similar.

Embedded Training Capability

The ET capability will be accessed from the operating system level. A unique command will be provided to call up and begin the ET component, separate from normal Product functions. This capability allows "off-line" training to prepare new users of the Product to learn its functions and capabilities, as well as review or sustainment for more experienced users. The Product Four ET component will contain the following functional capabilities:

1. Modular Lessonware: Specific topics will be organized into lessons, which can be taken independently by a user. An overall syllabus structure will guide initial training, but the user will not be constrained to take the training modules in any specific order. Following of the syllabus structure for new users will be encouraged, however. We presently anticipate the following major lesson topics for the syllabus:
 - a. Basics I - Introduction to the Training Characteristics Estimation Method and Software System

- b. Basics II - Input Data Requirements and Data Input Practice
- c. Basics III - Understanding and Interpreting Comparison System Outputs
- d. Basics IV - Understanding and Interpreting Training Characteristics Estimates
- e. Basics V - Understanding and Interpreting High Driver, Design Problems, and Design Principles Data
- f. Advanced Topics I - Sensitivity Analysis: Why and How
- g. Advanced Topics II - How the Training Estimation System Works
- h. Advanced Topics III - Adjusting Composite Comparison Cases
- i. Advanced Topics IV - Adjusting Training Characteristics Estimates
- j. Advanced Topics V - The Role of Subject Matter Experts and How to Use SME Information

The first five modules are designed to enable the first-time user to utilize the Product to derive basic training characteristics estimates. The last five deal with advanced topics for more experienced or interested users, or those who need to use the more advanced capabilities of the Product.

- 2. Guided Practice and Worked Examples: Much of the training provided by the ET component will consist of hands-on exercises with extensive guidance for the user. Exercises will concentrate on accomplishing specific steps of using the Product, and will contain error diagnostics (comparing the user's performance with that of an idealized Product Four user) to enable feedback and learning from errors.
- 3. A Balanced Mix of Knowledge and Hands-on Training: Some users will be uninterested in "how the Product works," and will wish to emphasize practical capabilities. Others will develop an interest in how the Product does what it does to produce its outputs. The content and structure of training will accommodate both extremes, as well as many intermediate points on the "theory-practice" continuum.

4. Checkpoint and Resume: We recognize that the Product's users are busy people with many demands on their time. We will therefore not constrain the user to dedicate time to complete even a single module of training at one session. Each user's progress in training will be monitored by a control feature in the ET component, and a user will be able to suspend training at any point and resume from the same point at a later time.
5. Basics and Advanced Product Use: When users are tasked to develop training characteristics estimates, it is likely that fast response will be particularly important. Thus, we will structure training to enable the user to work with basic features and capabilities of the Product first. If the user later has time and interest, he or she can "add on" training in how to work with such features as the sensitivity analysis capability or adjusting initial estimates given more complete data or access to SMEs.

We anticipate that the ET component will be capable of enabling a completely naive user to develop basic, "no-frills" training characteristics estimates for a new system after a maximum of fcur hours' training time, given straightforward and reasonably complete system and subsystem characteristics data for the contemplated new system.

Context-Sensitive Help and Explanation Facility

This facility will enable the user to request help and explanations at any time the user is actually interacting with Product Four. Context sensitivity of this feature refers to the fact that the Product will have information about what the user is attempting to accomplish during any interaction. Using this information, the Product will provide guidance and explanations of how to accomplish the particular function. The Product will also be able to present information regarding why particular inputs, judgments, etc. are needed to accomplish the interaction. Guidance will always be provided when the user invokes the help capability. "Why" information will only be presented at the explicit request of the user.

The user interface with the help and explanation capability will be through a "hot-key" approach, with one function key (or the equivalent) always set aside to request help. If the information contained in the help or explanation requires more than one full display screen to present, the user will utilize the normal up and down cursor-control or scrolling keys to move forward or backward through the information presented. If there are options, choices, or responses associated with a help or explanation display, the user will be

presented with a "pull-down" menu of choices, above the normal display area for help information. Choices will be made by moving a block cursor to the desired option or response (using the left and right cursor control keys) and using an "enter" or execute key to invoke the choice desired.

SECTION EIGHT
PRODUCT FOUR ACCEPTANCE

Our entire approach to the design and development of this Product is intended to foster both user acceptance of Product Four and acceptance of its outputs by those who use them. Specifically, we do this in the following ways:

1. We identify in detail what the Product should produce as its outputs, for each potential class of user. This works to ensure the Product's acceptability by providing what is genuinely useful to the users of the outputs, rather than something else.
2. We involve Product users in the design and testing of the Product. This ensures that we will be able to design out features or characteristics of Product operations and the user interface which could work to reduce Product acceptance. This also gives some "ownership" of the Product to at least some of the people who will use it.
3. We make the Product very easy to learn and use, by designing the user interface for maximum comprehensibility and support, and providing Embedded Training for users. This tends to overcome resistance to new techniques and reluctance to use the Product which would exist if the Product were more difficult to use.
4. We provide constantly available, context-sensitive help for Product users. This helps to avoid or reduce frustration that might develop in using the Product, if users become "stuck" or at a loss for what to do next while using the Product.
5. We ensure users are able to understand what data are required to operate the Product, through using data models or templates to guide data input. This also helps to avoid frustration in using the Product.
6. We provide a large number of defaults, even in input data requirements, so that users are able to work with the Product even in cases where data are scant. This assures that the user will be able to generate at least "something" which is face-valid as a result of using the Product.
7. We consider all the classes of users in the design of this Product. This is especially important, since there are

multiple classes of users. The data generated by using the Product have been designed to satisfy user requirements to the maximum extent possible, given users' characteristics and data needs.

8. We consider the context in which the Product will be used. We recognize that Product Four will be used very early in the acquisition cycle, to both develop constraints for MANPRINT characteristics of systems, and to influence system design to minimize training. This is reflected in several of the measures discussed above.

In addition to these approaches, the approaches we will take to institutionalize Product Four (see Section Nine) will help to ensure acceptance and use of the Product and its outputs.

SECTION NINE
INSTITUTIONALIZING PRODUCT FOUR

There are two approaches that will be used to institutionalize the Product. One is "campaign" actions that will be taken to institutionalize the Product. The second is to build into the Product characteristics that will help insure its institutionalization (inherent characteristics).

Campaign Actions to Institutionalize the Product

The institutionalization plan includes three campaign action items. These are:

1. Involving potential users in the development process;
2. securing the support of a general officer; and
3. teaching Product use to combat developers within their training course.

The first part of the institutionalization plan, chronologically, will be getting the potential users of the Product involved in all stages of its development. The potential users will be involved in the design and testing stages through both informal commenting and more formal pilot-testing. A frequent dialogue will be established with the more cooperative potential users. They will be asked for input on database item and structures, and interface design, in addition to the more basic procedures of the Product.

Potential users include the combat developers "in the trenches" at each of the schools. In addition, their superiors up to the typical heads of the combat developments directorates (Colonels) will be encouraged to become involved in the development of the system. Similarly, appropriate personnel at headquarters TRADOC also will be involved. Finally, AMC personnel also will be encouraged to participate.

The reasons for the involvement of the potential users are:

1. To develop a critical mass of positive potential users prior to the availability of the Product. They will help institutionalize the Product by using it and promoting it.

2. To obtain data from the potential users to help tailor the Product more to their needs and desires. This will make it a more attractive Product and thus help insure its institutionalization.
3. To be able to say we consulted with the users in the development of the Product and that we have their support and approval.

The second campaign action item will be to obtain the support of a general officer. This will be accomplished after the Product is partially developed, so that its rudiments can be shown and demonstrated to help obtain support. Also, the interaction and support of the users will be marshalled to gain the support of a general officer. In addition, briefings and white papers will be used to extol the efficiency, cost, and other benefits the Product will yield.

The third campaign action item is to have the use of the Product included in the course taught to combat developers. It should be possible to include a new "piece" in the course specifically devoted to promoting the Product. In addition, the course will teach the combat developers how to use it and make them familiar and comfortable with it. All of these additions to the course will help institutionalize the Product.

Inherent Features Fostering Institutionalization

There are six specific features which will be inherent characteristics of the Product or results it will yield which will foster its institutionalization. The six are:

1. Face validity;
2. Reduces labor;
3. Lowers cost of combat developer's process;
4. Lowers cost of system development;
5. Produces a formatted audit trail; and
6. Helps develop O&O plans.

Face validity will come through interaction with the users during the development and testing of the Product. Face validity will go a long way toward institutionalizing the Product. Face validity will partially result from the users' feedback during the design and development process. Such feedback will provide guidance for the design and development of the Product. This will help to assure that

users have some "ownership" in the Product, and that it will meet their needs effectively.

Obviously, the Product will result in a reduction of the amount of labor required by combat developers to produce training estimates. This feature can almost in and of itself cause it to be institutionalized. Many system development efforts have resulted in elegant systems that were never used. Often this was because the systems required the users to do more than they did before. On the other hand, everyone appreciates a job aid that actually makes their job easier, especially if it is because they have to do less. The reduced labor on the part of combat developers also may result in their training estimation process costing less.

Similarly, the Product will lead to a lower cost for the development of systems than was previously experienced. This will be the result of having specific training constraints available before system design, alleviating costly modifications that would have to occur if training requirements of the new system were excessive. Costly redesign efforts prior to developmental testing and any retro-fitting after operational testing may be avoided. In addition, designing the system to meet specific training constraints also may help the system avoid some product improvements after fielding. All of these reduced cost aspects will be effective in obtaining the support of a general officer.

The Product will result in a formatted audit trail which will document each training estimation effort. This is an especially attractive feature of the Product, because the present training estimation process often leads to unanswerable questions about decisions and outputs. Part of the reason for the present process resulting in unanswerable questions is that the process is not proceduralized and thus requires more of an audit trail than a proceduralized one. Moreover, the present process provides no format or easy to use vehicle for generating an audit trail.

Finally, the Product will help combat developers produce an O&O plan. Again, any time a new product makes someone's job easier, the product has a high probability of being used and thus being institutionalized.

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MANPRINT METHODS MONOGRAPH:
AIDING THE DEVELOPMENT OF TRAINING CONSTRAINTS

PRODUCT 4 FINAL CONCEPT PAPER
TRAINING ESTIMATION METHODOLOGY

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PRODUCT 4 FINAL CONCEPT PAPER
TRAINING ESTIMATION METHODOLOGY

INTRODUCTION

The Problem

The Army is heavily involved in training. In fact, under peacetime conditions, almost all Army activities can be considered as training of one kind or another. These training activities range from resident school instruction--Basic Combat Training (BCT) and Advanced Individual Instruction (AIT)--to both formal and informal on-the-job training (OJT) conducted in a variety of locations. Training constitutes a multibillion dollar activity requiring the support and involvement of a large portion of available Army personnel.

One aspect of the Army's training activities that has received considerable attention during the recent era of widespread force modernization is the process by which training requirements and constraints for emerging systems are determined. Under current regulations, Army combat developers are required to determine a proposed system's training needs early-on (i.e., during concept exploration) and use the resulting information both to: (1) constrain materiel design, and (2) lay the groundwork for deploying the eventual training system concurrently with the materiel system.

In spite of the firm regulatory emphasis, the Army's actual early-on training estimation process does not work as intended. In most system development efforts, training considerations are not used to constrain equipment design, and the actual process of fielding the training system often lags far behind the materiel acquisition itself. As a result, systems are often fielded without a fully-developed training support package. Moreover, the training that is eventually provided often is not sufficient to bring trainees to the performance levels necessary for military success.

The research and development called for under the current effort is in direct response to the problem alluded to in the previous paragraph: An undisciplined system development process in which weapons are designed without regard for personnel constraints--manpower levels, aptitude distributions, and training capabilities. When this undisciplined process is applied to system after system, the result is a cumulative demand for skilled personnel that is beyond the capability of the Army to satisfy. The specific focus of Product 4, referred to in the current paper as the Training Estimation Methodology (TEM), is the process by which training requirements and constraints are

identified early-on and are used to influence both later training system development and materiel system design and employment concepts.

Objectives

The Statement of Work (SOW) for the present effort describes the TEM as, "...a product that will aid TRADOC and DCSPER MANPRINT personnel in providing a quick estimate of the types of training and the maximum training times that are likely to apply prior to preliminary design. The purpose of this product is to determine the probable parameters of training so that hardware and software designers know the training limits and do not design for unavailable training." The SOW goes on to state that, "... this training estimate is made prior to initial system design by providing limiting information to hardware and software designers. ... the purpose is not to identify what training ought to be, but to tell designers what it is likely to be so that hardware and software designs do not require types and amounts of training which are very unlikely to be made available."

Our interpretation of the language in the SOW is that the sponsor (i.e., the Army Research Institute [ARI]) desires a training estimation methodology with the following general characteristics:

- It can be used quickly
- It must be usable prior to initial design
- It must identify the constraints boundary for a proposed materiel system's training system
- It must identify what training is likely to be, rather than what it ought to be
- It must provide results usable by personnel developing training programs as well as hardware and software interface designers

In other words, the objective of the TEM is to provide a rapid, early-on assessment of the most probable architecture of a proposed materiel system's associated training system. Information regarding the most probable training system architecture, or training concept, if you like, is to be used as: (1) a basis for follow-on training development, and (2) to influence the design of the materiel system itself. The SOW makes the point that a primary objective of the TEM is to constrain system design by providing information regarding training parameters so that system designers do not design for unavailable training.

A Definition of "Most Likely Training"

Our experiences concerning the way in which the Army develops training have indicated that "most likely training," or that training which emerges from the Army's de facto training design and development process, is most often a function of the following influences:

- The predecessor (or a referent) system's training program
- Documented deficiencies in the predecessor training program
- Unique or new training requirements imposed by a new materiel system
- The proponent school's "world view" regarding training
- The available and projected resources base
- Advances in training technology

The Army rarely duplicates a predecessor or referent training system. Rather, the training system for a new materiel item usually represents a complex compromise between training needs, various types of constraints, institutional biases, past practices, and technological advances (i.e., what's "hot" now, training-wise). (Note: The current emphasis on embedded training is a good example of the "what's hot now" phenomenon). Most new training systems can thus be characterized as consisting of training program modifications fit within explicit constraints. The term "most likely training" will thus be defined, for purposes of the current discussion, as a training system modification (usually an upgrade) accomplished within constraints. It should be further noted that such training system modifications will be achieved in an evolutionary as opposed to revolutionary fashion. It is also recognized that a system developed in such an evolutionary manner will rarely be characterized by training professionals as "ideal" or "optimal."

Approach

In view of the above definition, the problem of developing the TEM is thus reduced to two major tasks. The first is to define a practical methodology that will aid Army analysts in predicting or defining the scope of training system evolutionary modifications that can be fit within existing or projected constraints. The second is to ensure that the methodology is institutionalized and used by analysts early-on in the system acquisition process. As noted in the SOW for the current effort, ensuring the use and acceptance of a methodology is one of the critical elements of a solution to any of the MPT estimation problems.

We believe that the user acceptance problem is the most difficult of the two tasks which must be accomplished in development of a viable TEM (Product 4). Review of the military training literature indicates that a number of training development aids have been developed but none have gained widespread use or acceptance within the Army. If previous attempts to aid analysts in determining training requirements have failed to gain acceptance, the problem of gaining acceptance of a methodology to predict the "most likely training" will be substantial. This assertion is based on the simple fact that analyses to determine training requirements are likely to be perceived as a more critical need by Army training analysts than prediction of "most likely training." Since decision aids to support the former need have failed to gain widespread Army acceptance, the design of a methodology to predict "most likely training" must be highly sensitive to user acceptance if it is to have any chance of success.

The key to designing a TEM which will be used by analysts throughout the Army is to understand the problems they must solve and the environment in which they work. The Army, specifically the Training and Doctrine Command (TRADOC), has a very elaborate and well-defined formal process for training design and development. This system has the formal charter for all early-on training design and development activities. If early-on training design or development results are to have official sanction, they must flow from or at least receive the imprimatur of this formal system. Hence, the TEM must conform to the general requirements of the formal TRADOC system if it is to have any chance of being accepted into the stable of sanctioned training analysis tools. In fact, it can be stated categorically that the primary reason that previous efforts to institutionalize TEM-like methodologies (and there have been several) have failed is that they have not been accepted by the formal system. With this fact in mind, one of our primary, non-technical objectives for the TEM is that it be orthodox; the methodology must be perceived as being in complete conformity with TRADOC's formal regulatory apparatus and possess enough flexibility to accommodate procedural variations at each of the local combat development centers.

The focus on user acceptance and institutionalization of the TEM is the "high driver" guiding the development of the concept for Product 4 presented in the current paper. The two other problems noted in the SOW (obtaining data to conduct the required analysis and development of information provided by the MPT estimation product) have to be solved within the design constraints dictated by the user environment. The MPT estimation tools (like any system to be analyzed using MPT estimation tools) must be designed considering the "performance of the soldiers who operate, maintain, and support their hardware and software."

Organization of the Concept Paper

The remainder of the concept paper is organized to provide the information required by the SOW and to present a detailed discussion of the approach the current authors believe is required to develop a viable Product 4. Section 2 of the paper presents a detailed analysis of the regulatory environment in which the users of Product 4 must operate. To gain acceptance, Product 4 must contribute to the accomplishment of tasks existing in this environment. Included in this section of the concept paper is a description of the projected users of Product 4. Section 2 ends with a discussion of the design constraints for Product 4 dictated by the user environment.

Section 3 of the concept paper discusses the structure and function of the TEM. Included in this section is a description of the data required to exercise the TEM and a discussion of the output generated by the methodology. Other issues discussed in Section 3 include how the TEM will be developed, how it will train its users, and estimates of the person-hours required to use the TEM to identify the "most likely training" for a system in the concept development phase.

THE TEM USER ENVIRONMENT

Introduction

The overall context for the application of the suite of early-on Manpower, Personnel, and Training (MPT) estimation tools called for under the SOW is the Army's Weapons System Acquisition Process (WSAP). A myriad of regulations and documents (e.g., AR 70-1, DA PAM 11-25, TRADOC/AMC Pamphlet 70-2, etc.) describe the process by which the Army acquires materiel systems and addresses human performance issues as part of the developmental process. For purposes of the current effort, the Army's systems development process can be viewed as proceeding much as depicted in Figure 1. Periodic Mission Area Analyses (MAAs) are used to identify threat-related deficiencies on the part of the current force. In response to mission area deficiencies, an evaluation is made of ways in which a capabilities gap can be closed. Issues that are addressed first in this regard include: (1) an evaluation of potential doctrinal or tactical adjustments, (2) manpower or personnel solutions, and (3) training solutions. If a deficiency cannot be redressed through doctrinal, tactical, or MPT means, then a materiel solution might be sought.

If a materiel solution to mission area deficiencies is decided upon, the initiating documents for the developmental effort are the Justification for Major System New Start (JMSNS) and the Organizational and Operational (O&O) Plan. In theory, at

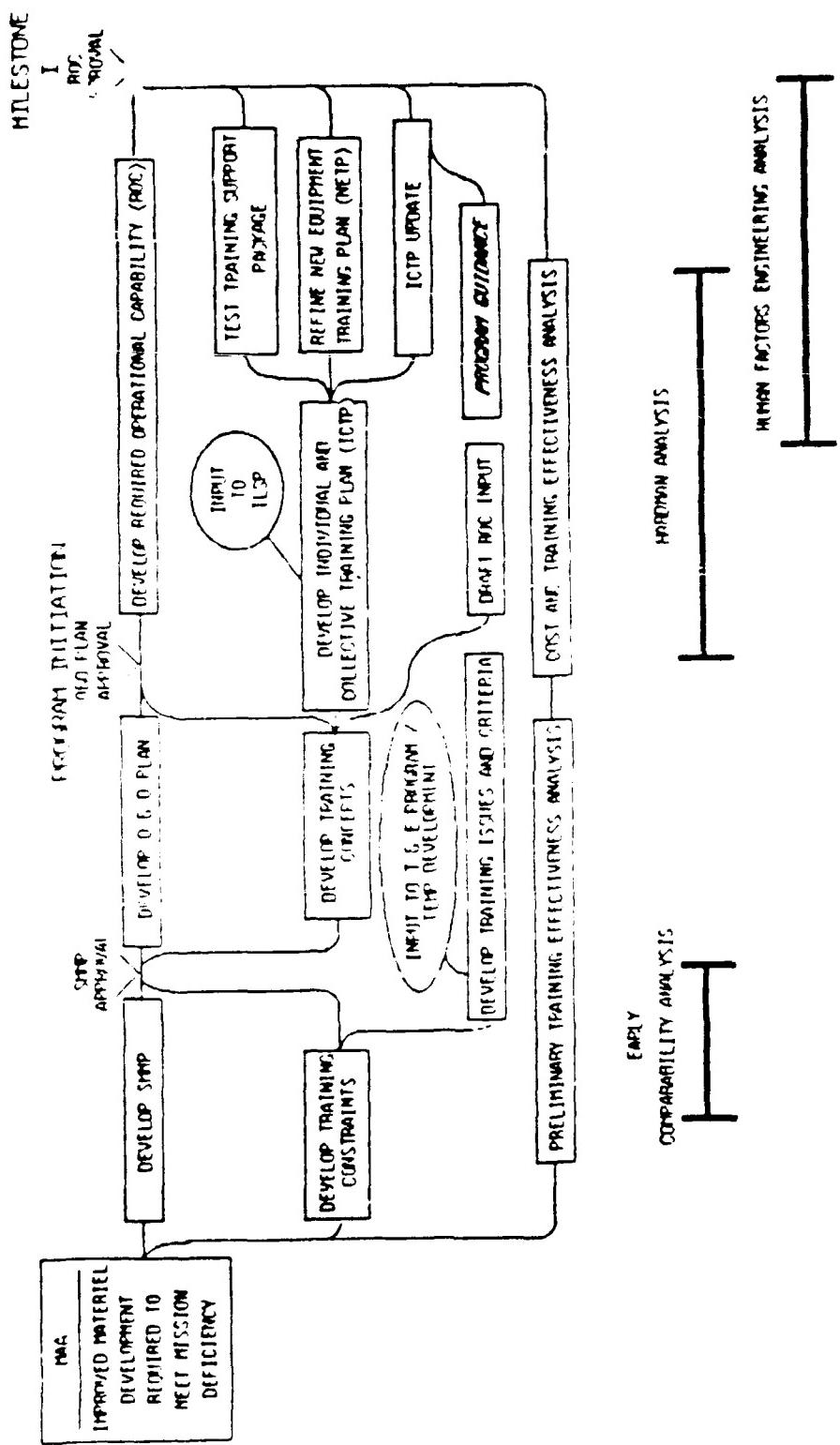


Figure 1. Early training activities

least, both the JMSNS and the O&O Plan are to reflect MPT constraints. At present, however, MPT issues are given only cursory treatment in these documents.

TRADOC/AMC Pamphlet 70-2, Materiel Acquisition Handbook, describes policy, procedures, and responsibilities for acquiring materiel systems. Recently (August 1985), TRADOC released detailed guidance concerning the consideration of the six MANPRINT (Manpower and Personnel Integration) domains during the development of all materiel items. This guidance is organized around the following five topics:

1. System MANPRINT Management Plan (SMMP)
2. Manpower and Personnel
3. Training
4. Human Factors Engineering
5. System Safety and Health Hazard Assessment

Requirements for Early-on Training Analyses

A review of Section 3 of the TRADOC guidance indicates that training activities in support of the materiel acquisition process are to begin prior to Program Initiation. Figure 1 shows the general flow of training activities beginning with the identification of a need to develop a materiel item through Milestone I. The Directorate of Training and Doctrine (DOTD) at the proponent school is, in almost all cases, responsible for the conduct of these activities. Also shown in Figure 1 are the major analyses to support MANPRINT. These analyses, though not specifically training related, can provide information which is useful in developing training concepts and in determining potential problem areas. The primary objectives of these activities can be characterized as follows:

- Develop training constraints within which the Army must tailor new training required as a part of the developed materiel item.
- Develop training concepts that can potentially satisfy the training requirements associated with the developed materiel item.
- Determine the most cost-effective approach to development and delivery of required training.

Each activity is addressed in more detail in the paragraphs to follow.

The responsibility for developing training constraints is vested with the proponent DOTD - New Systems Training Office

(NSTO). Constraints should be developed from guidance, lessons learned, MAAs, Post-Fielding Training Effectiveness Analyses (TEA), or an Early Comparability Analysis (ECA). A list of constraints should be developed and included in the O&O Plan and the SMMP. These constraints should also be considered as the Individual and Collective Training Plan (ICTP) is developed. Specific training constraints should include information concerning the treatment of high-driver tasks, time-to-train limits, instructor limits, and the like.

Once training constraints are established, there is no formal provision for revising them. However, because training constraints are included in the O&O Plan, there is an opportunity to review training constraints prior to Milestone I. Training constraints may also be included as part of the Required Operational Capability (ROC). When this is the case, a review of the ROC may result in specific program guidance addressing the adequacy, accuracy, or completeness of training constraints.

The proponent DOTD - NSTO also has the responsibility for developing the training concept for the emerging materiel item. According to TRADOC Regulation 350-4, this process involves the identification of generic training tasks, course requirements, training sequences and locations, and an initial estimate of training equipment and devices that will be required. Alternative training approaches and concepts should be included for later cost evaluation. This activity is expected to be iterative in nature, particularly if the doctrine associated with a new system is still under development.

Information developed in support of the training concept should then be used as a basis for the draft ROC training paragraphs and annexes. Further refinement of the training concept will also occur in the development of the ICTP. Although not currently specified, training concept development could be very useful in identifying potential training problem areas. It also presents the proponent with an opportunity to incorporate new training technologies which might reduce training cost, manpower requirements, or time. In general, the training concept is expected to undergo continual refinement and progressive resolution over the course of the acquisition.

The ICTP is the capstone document for all training concepts. According to TRADOC Regulation 351-9, the "ICTP must present a systematic, workable strategy for training from initial qualification through sustainment of that proficiency ... and for training required to qualify personnel on the higher-level tasks associated with the equipment as they advance in grade." A major pitfall to be avoided when developing the training concept presented in the ICTP is to fix on concrete training solutions (i.e., explicit alternatives) too early in the acquisition process.

Cost-effective training approaches are determined within the context of the TEA system. The TEA process is divided into two broad categories: (1) developmental TEAs (DTEAs), and (2) post-fielding TEAs. The post-fielding TEA is not applicable to the initial phases of the materiel acquisition process. As the name implies, it is conducted after the materiel item is provided to units. The DTEA consists of three elements: (1) a Preliminary Training Effectiveness Analysis (PTEA), (2) the Cost and Training Effectiveness Analysis (CTEA), and (3) the Training Development Study (TDS).

The Preliminary Training Effectiveness Analysis (PTEA) is conducted to facilitate the development of training concepts and strategies (TRADOC Regulation 350-4). In general, the PTEA should address the target audience, the identification of skills to be trained, and a first cut at the "when, where, and how" of training. The PTEA is intended to support decisions at the end of the concept exploration phase, Milestone I of the WSAP. This information also provides a basis for developing the Outline ICTP (OICTP).

The Cost and Training Effectiveness Analysis (CTEA) is characterized as a detailed analysis of the comparative effectiveness and cost of the training alternatives developed to support a new materiel item. By regulation, the CTEA is intended to: (1) establish the proficiency attained by different training alternatives, (2) determine their cost, (3) perform a cost-effectiveness trade-off, (4) recommend a preferred training alternative, and (5) verify or amend the training concept and strategies presented in the OICTP. The CTEA will support decisions at the end of the demonstration and validation phase, Milestone II of the WSAP.

The purpose of the Training Development Study (TDS) is to evaluate the efficiency of a training device or simulator prior to full-scale production. According to TRADOC Regulation 350-4, a TDS "must analyze the cost and effectiveness of a simulator and how it will support training for a fielded system or non-system training program." It can be performed as part of a PTEA, CTEA, or CTEA update.

Summary of the TRADOC WASP Training Analysis Requirements

In summary, the formal TRADOC training design and development system described in the previous paragraphs defines a two-level process for early-on training requirements definition. The first level of the process is embodied in the PTEA. This analysis is to be performed prior to Milestone I when only system concepts exist. Again, the objective of the PTEA is the performance of preliminary analyses and design activities directed at training concept development. By regulation, the PTEA is to examine: (1) training constraints; (2) potential training problems; and (3) the definitions of a training system

concept addressing (a) what is to be trained, (b) who is to be trained, and (c) a first cut at the "when, where, and how" of training. An initial TDS addressing training device concept development can also be performed as part of the PTEA. Output from the PTEA is used to structure the OICTP.

Level two of the formal process training development process is the CTEA. The CTEA is performed prior to Milestone II during demonstration and validation when materiel system prototypes exist. It consists of detailed analysis and design activities directed at individual course (i.e., MOS-specific training) development, including a detailed consideration of training device requirements. Conceptually, the CTEA is performed within the context of the system-wide training architecture defined at the PTEA stage. Output from the CTEA provides the structure for individual course development and is used to transform the OICTP into the ICTP.

The Realities of Early-on Training Analysis

The description provided in the previous paragraphs is of the manner in which the Army's early-on training analysis and design process is supposed to work, not how it actually is carried out. Needless to say, the consideration of training during system development does not actually proceed as described in Figure 1. Most of the time, training issues are not addressed explicitly prior to Program Initiation. As a result, program initiating documents typically do not pay more than lip service to training issues (e.g., a token mandate not to require more training assets than the predecessor). As an added consequence, training constraints-related information is usually not available to system designers early-on.

Between Program Initiation and Milestone I, the training-related actions described in Figure 1 are usually performed in a token fashion or are waived. As a result, the system's training concept is not addressed explicitly. Consequently, the system-level concept is defaulted away, and any ensuing analyses tend to focus immediately on the "nuts and bolts" of training for individual courses. Individual course development then proceeds in isolation with no training-system-level coordination or synergy. It has been our observation that the default treatment of the training concept brought on by not performing a comprehensive PTEA early-on is one of the primary reasons for the poor track record attributed to the Army's formal training design and development process.

At a more specific level, some of the symptoms of the lack of an early-on, system-wide focus for training include the following:

1. There is considerable confusion over the split between training concept development and the development of training

alternatives within that conceptual framework. In other words, training development personnel tend not to understand the rationale for the PTEA/CTEA split; the PTEA and the CTEA are viewed as addressing the same issue, which is not the case at all. As discussed above, the result is that the all-important training concept development step often is not performed.

2. Early-on training design and development is late and out of synchrony with the rest of the system development process. Typically, training issues are not considered explicitly within DOTD - NSTO until after Milestone I (i.e., not until the CTEA is initiated). By that time, however, the training "metal is bent," quite literally, in the form of very explicit training device concepts. The training community is then relegated to doing what has been termed "Procrustean training analyses" to justify a proposed training device concept that may or may not be warranted learning-wise or even cost-effective. Procrustean training analyses are training analysis and design activities performed to accommodate an existing training device concept. Under such a procedure, training devices are proposed first, and the remainder of the training program then constructed around the major devices. The term is derived from the mythical Greek bandit Procrustes and his infamous bed.

3. There are no standardized procedures for the conduct of PTEA or CTEA. This observation is particularly true for PTEA. Various CTEA methodologies and supporting tools exist (see Adams & Rayhawk, 1986), but the Army has not yet determined a standard version. As a result, a "Tower of Babel" syndrome exists within the TEA world. TRADOC schools both conduct in-house and contract for various TEAs. Given the divergence of methodologies, however, there is no assurance that any two analyses will stem from the same conceptual reference point.

The TEM Concept in the TEA Environment

Based upon a review of the way in which the Army's TEA system (the formal basis for Army training design and development) is implemented, the most obvious deficiency is the PTEA. As noted previously, the PTEA is to be performed during concept exploration for the expressed purpose of: (1) determining constraints, (2) identifying problem areas, and (3) formulating a system-wide training concept. A review of the objectives of Product 4 (i.e., the TEM) as outlined in the SOW indicates similar objectives. Given this similarity in objectives, we have determined that the most effective way of meeting the requirements of the current effort and producing a tool that will gain acceptance and be used in the Army is to develop a methodology to support the conduct of PTEA.

The decision to develop a TEM designed to aid in the conduct of the PTEA allows the identification of the users of the product as well as specification of certain attributes the TEM must

possess. The paragraphs which follow briefly describe the user audience and the design characteristics which the TEM must possess to aid in the PTEA process.

The TEM Users

The conduct of the PTEA is the responsibility of the Directorate of Training and Doctrine - New Systems Training Office (DOTD-NSTO) of the proponent TRADOC Combat Development Center for the new system. Thus, the staff typically found in the DOTD-NSTO can be assumed to represent the users of the TEM. Experience indicates that the composition of the staff working in the DOTD-NSTO varies from one school to the next, but typically includes Army majors and captains, one or two civilian training analysts, and Subject Matter Experts (SMEs) who are often senior enlisted personnel. Thus, the "team" using the TEM may be expected to have a reasonable familiarity with the training analysis process (as practiced at that proponent school). The team will also include, or at least have access to, SMEs with knowledge relevant to the predecessor systems for the new system under analysis.

The team using the TEM will also likely contain several members who are capable of using a computer terminal or micro-computer. While the TEM users can be assumed to have a minimum degree of familiarity with using micro-computers or terminals, one cannot assume familiarity with any particular software system.

Our previous experience in working with individuals in the DOTDs for several proponent combat development centers also suggests certain biases regarding analytic tools. First, the users tend to be reluctant to use any tool that is not fully understandable to them. In particular, these individuals are particularly sensitive to assumptions made in any transformation of data and the rules or algorithms used during analyses. Furthermore, the users tend to prefer tools that allow them to generate and compare alternatives over time as new information comes available.

Finally, it is safe to assume that the TEM users will operate under fairly severe time constraints. Combat development centers typically carry a heavy workload with a minimum of personnel. In recent years these centers have experienced increased taskings with no increase, and in many cases, with a reduction in personnel. Thus, the TEM user will need a methodology which is as time efficient as possible.

Objectives for the TEM

The decision to develop a TEM which supports the PTEA process allows us to identify several specific issues which must

be addressed to gain user acceptance of the TEM. In pursuing the development of a comprehensive PTEA methodology, the following objectives will be addressed:

1. Orthodoxy. The TEM must meet TRADOC's formal requirements for a PTEA methodology as outlined in TRADOC Regulation 350-4 and other documents describing the systems approach to training (SAT) design.
2. Sufficiency. At a minimum, the TEM must address the functional requirements for PTEA outlined by TRADOC and must meet the requirements of the current effort as cited in the SOW.
3. Standardization without over formalization. The TEM resulting from the present effort must meet the goal of standardization without over formalization. It is our objective to provide the Army with a standardized tool to support the conduct of PTEA. However, we do not want to over formalize the resulting procedure to the point where it becomes unnecessarily cumbersome or cannot accommodate local procedural variations. Over formalization is one of the primary reasons that many previous TEM-like tools have not achieved their design potential.
4. User Friendly. The procedure must be readily usable by personnel representative of DOTD-NSTO job incumbents.
5. Economical. The procedure must not require more resources--people, money, technical support (computers, software, etc.)--than is currently available within a typical DOTD environment at a combat development center.
6. Synchrony. The TEM must assist in fostering a synchrony between training-related acquisition events and materiel-oriented aspects of the system development process.

Overview of the Structure of the TEM

At the present time, we conceive of the TEM as a three-part methodology, with each part being referred to as a "module." The TEM is a computer assisted analytic methodology. It is not a fully automated model. That is, the automated portions of the TEM guide the user through an analytic process including prompting the user for data, identifying potential data sources, constructing data bases, performing analyses, and generating reports. The wide variety of systems for which the TEM might be applied, variation in the amount and quality of data available for different systems, and a variety of other factors require that the user play an active role in the TEM. The three modules comprising the TEM are listed and described as follows:

- Training Constraints
- Training Analysis

- Feedback and Interface

Briefly stated, the objective of the Training Constraints Module is to assist training developers in identifying relevant constraints within which an emerging training system must fit. Constraints identified include resources, technology, world view, training program performance history and potential, and other similar information.

As the name implies, the Training Analysis Module is intended to lead analysts through a series of procedures that support the definition of a system-wide training concept. The resulting training concept will address, at a generic level, the "what, who, how, when, and where" of training. It will also enable the conduct of an early-on TDS directed at the definition of a range of training device concepts that conform with the overall training concept. Training concepts emerging from the analysis stage will all be achievable within the limits identified through the exercise of the Constraints Module.

Finally, the Feedback and Interface Module is intended to serve as the link between the TEM and follow-on training design and development activities, most notably the CTEA. This module is also intended to serve as a vehicle for structuring training-related feedback to concept developers and materiel designers, both inside and outside of the Army.

Additional details concerning the TEM concept and how it will fit within TRADOC's formal training development process are provided in the next section, The Training Estimation Methodology.

THE TRAINING ESTIMATION METHODOLOGY

Overview of the TEM

The SOW for the present effort indicates that Product 4, referred to herein as the TEM, is intended to be a tool that will provide combat and materiel developers with an outline of the training "most likely to be made available" to support an emerging system. In Section 1, we further defined the term "most likely training" to mean the scope and nature of training system modifications that can be accomplished within broad classes of constraints.

Section 2 made the point that our overall concept for the TEM is to develop it as a partial guide to the conduct of PTEAs. The PTEA is an essential aspect of the TRADOC TEA system, but one that is not often performed. As noted earlier, the PTEA is intended to address: (1) training constraints, (2) potential training problem areas, and (3) the development of a system-wide training concept. In accord with this view, the TEM will be developed in three interrelated parts, or modules, listed as follows:

- Training Constraints
- Training Analysis
- Feedback and Interface

TEM Structure

A graphic description of the overall TEM concept is presented as Figure 2. Each of the component modules is now described in an overview fashion. More detailed descriptions of the modules follow under their own headings.

The objective of the Training Constraints Module (TCM) is to assist training developers in identifying and characterizing relevant training constraints for an emerging materiel system. As shown in Figure 2, input to the TCM consists of information concerning:

- Emerging system concepts
- Predecessor or referent system(s) and their training program(s)
- Training-related Manpower and Personnel constraints: Training manpower likely to be available; and the personnel footprint of the predecessor system, often

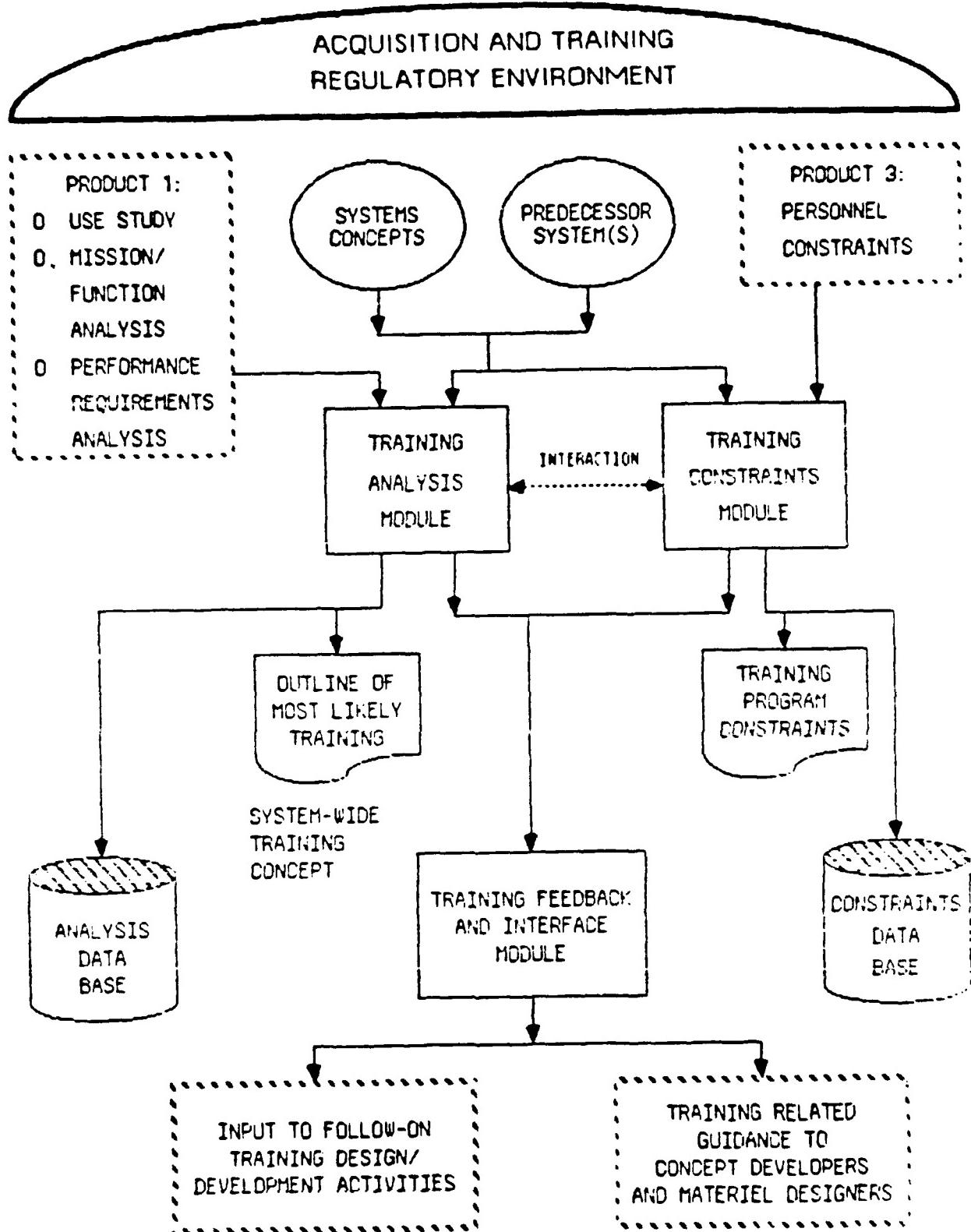


Figure 2. Overview of the training estimation methodology

referred to as a Target Audience Description (i.e., output from Product 3 of the current effort)

Using guidance provided by the TCM, users are led through a series of steps leading to the identification of the following classes of training constraints:

1. Resources. A description of the training resource base likely to be available to support the emerging system.
2. Technology. A characterization of the technological state of the training base likely to be available to support the proposed system.
3. Proponent's World View. A characterization of what DoD, the Army, TRADOC, and the proponent school think about training in general and training for the proposed system.
4. Predecessor or Referent (i.e., a Baseline Comparison System [BCS]) System Training. The "what, where, and how" of training for the predecessor(s) or any referent system(s). This will consist of a complete characterization of any predecessor or referent training program.
5. Predecessor Training System Performance. The training capability and capacity of the predecessor or referent training system. This will include a treatment of training performance deficiencies obtained from post-fielding TEAs or other sources.
6. Manpower and Personnel Capabilities. Numbers of personnel available to staff the training system; descriptions of aptitude and abilities for target audiences; personnel-related high drivers on predecessor or referent systems.

Output from the TCM is structured as input to a constraints data base that is available to support early-on training analyses and from which various ad hoc reports can be derived.

The Training Analysis Module (TAM) is concerned with the development of a system-wide training concept within the boundaries of the constraints identified through the exercise of the Constraints module. Since it is conceived of as part of a PTEA methodology, the TAM must address: (1) what is to be trained, (2) who is to be trained (i.e., potential MOSS and target audience descriptions), and (3) the "how, where, and when" of training. As opposed to the CTEA phase of the TEA process and most of the current training estimation methodologies, the TAM will function at the concept level. Its purpose is to define the concept-level architecture of the total training system as opposed to the detailed structure of individual courses within that system. The TAM represents the analytical "core" of the TEM.

Input to the TAM consists of: (1) the information provided to the TCM, (2) information derived from the Constraints module, and (3) information from Product 1 of the present effort. As noted earlier, most likely training is defined as training system modifications accomplished within limits. The TAM will indicate the scope of beneficial upgrades; output from the TCM will delineate the boundaries within which potential training solutions must lie.

TAM output consists of the traditional what, where, when, how, order, and time parameters of training. However, as noted previously, the focus of the TAM is on the architecture of the total training system as opposed to the structure of individual courses. TAM analyses are thus conducted at a generic as opposed to course-specific level. The generic focus of the TAM is a key to making it a simple and easy-to-use procedure.

The final component of the TEM is the Feedback and Interface Module (FIM). The FIM is intended to serve as: (1) a mechanism for providing training-related feedback to system stakeholders, and (2) an interface between the PTEA phase of the TEA process and follow-on training analysis and development activities. Our concept for the FIM is that it will function as a query and report generation capability capable of producing both standard and ad hoc reports. Standard reports will consist of training products or documentation mandated by Department of the Army (DA) or TRADOC regulations. For these reports, both the content and format will be defined as part of FIM development. Ad hoc reports are special reports of a "what if" nature that are used to support acquisition decision making or later training design and development but are not easily anticipated. The FIM data base consisting of output from both the TAM and TCM will also be used to initiate the more detailed training design and development activities that occur as part of the follow-on CTEA process.

Operation of the TEM

The three modules of the TEM are designed to be implemented sequentially. The user should first exercise the training constraints module (TCM) to develop the various resource constraint data bases. The training analysis module (TAM) is then exercised to develop a description of recommended training for each of the task or function statements produced by Product 1. In the final step in the TAM, the user modifies the recommended training to fit within the resource constraints identified in the TCM. This final step provides the TEM's prediction of the "most likely" training to evolve for the emerging materiel system.

After the TCM and TAM have been exercised to develop the required data bases and conduct analyses, the Feedback and Interface Module (FIM) is used to generate a variety of reports.

The FIM provides a variety of data base query and report generation functions which will allow the user to examine and print the output of each major element or function of the TCM and TAM.

Each module comprising the TEM is discussed in turn in the sections to follow.

The Training Constraints Module (TCM)

Objectives

The primary objective of the TCM is to develop structured data bases which provide the user with information on resource and constraint factors influencing the training system that emerges for the materiel system of interest. The data bases will serve three functions in the TEM. The data bases provide:

- Information on training constraints required in the PTEA
- Resource availability boundaries for analyses conducted in the TAM
- Data used to identify potential training system problems

Overview of the Functioning of the TCM

Figure 3 provides a graphic overview of the TCM. The primary inputs to the TCM are:

- Training resource availability data
- Predecessor system training data
- Training technology data from PM-TRADE and TTA
- Manpower and personnel data from Product 3

The TCM uses this input to generate a series of constraint data bases. The data is used in the TAM to generate the "most likely" training output matrix for each task identified by Product 1 of the MPT Estimation tools. In this sense, the TCM is a preprocessor of data for the TAM.

The TCM is exercised to develop three major data bases related to:

- Training resource availability
- Predecessor system training resource consumption and problems

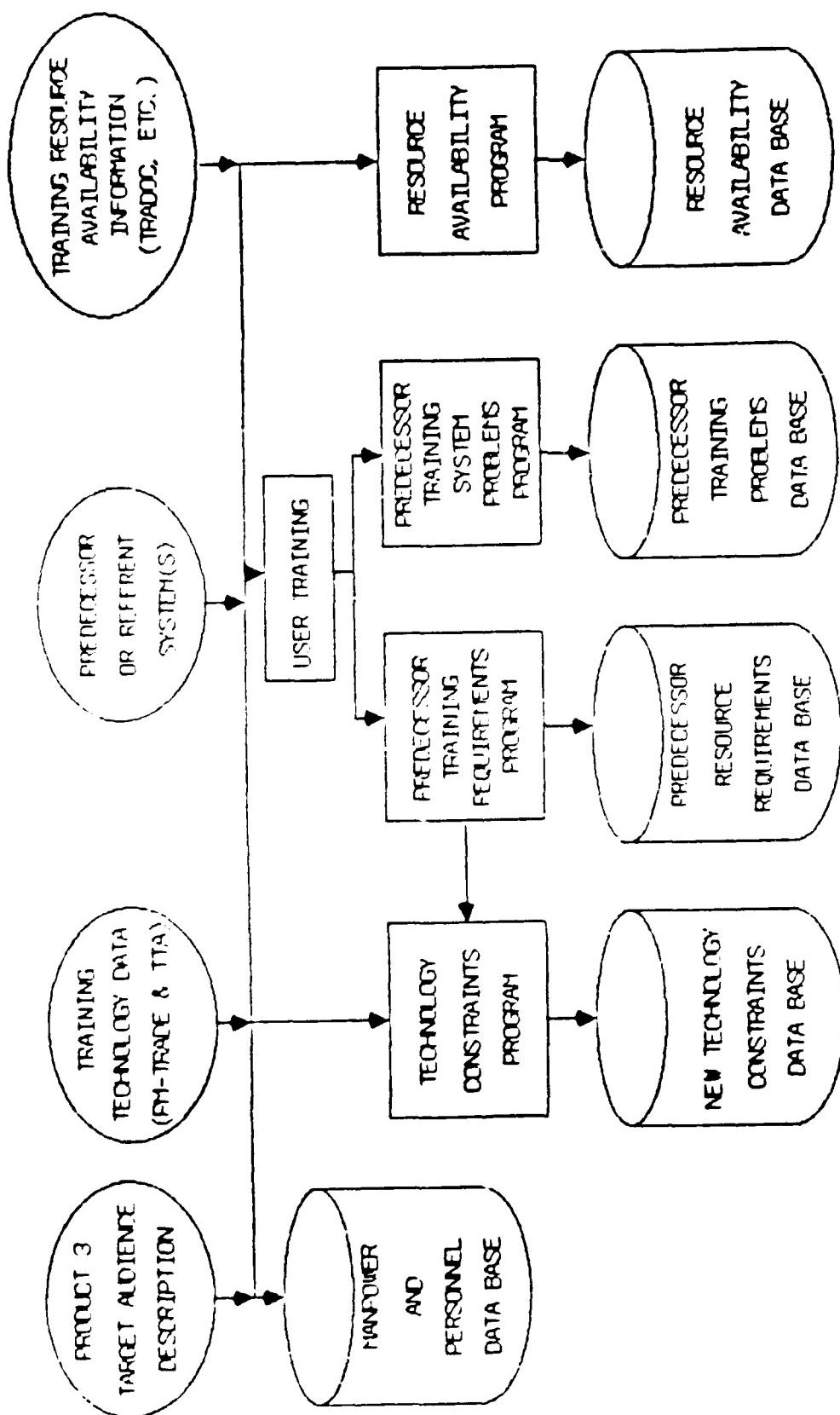


Figure 3. Training constraints module

- Likely availability of new training technology and methods

The three major elements of the TCM each represent a data base development function. In each case, the user will be guided by prompts on a computer to identify the structure of the data base and input information into the data base. Each of the major elements of the TCM also contains user help functions to guide the user to potential sources of information to aid in completing the data bases. The three major elements of the TCM are described in more detail below.

Resource Availability Data Base

The resource availability data base is the principal component of the TCM. The data base will contain estimates of the availability of critical training resources for the emerging materiel system of interest. These availability limits are used to set the boundaries for the estimate of "most likely" training produced by the TAM. Table 1 summarizes the data sources, structure, user inputs, user guidance, and output of the resource availability data base. Each of these elements of the data base is described below.

Data Sources. Preliminary research and discussions with SMEs in Army training development and system acquisition processes indicate that the data for the resource availability data base must be obtained from different sources depending on the training setting involved. The proponent TRADOC combat development center or school for the emerging materiel system will have the information required to answer resource availability questions concerning resident training. The \ training elements of the headquarters of the major U.S. Army commands of the "field army" such as FORSCOM, USAREUR, and WESTCOM can provide much of the data concerning training resource limits for on-the-job training in garrison. Additional information on training facilities, particularly facilities which are used by units from different installations such as the National Training Center (NTC) can be obtained from the office of the Chief of Engineers at the Department of Army. Projections on availability of new technology and simulator devices may be obtained from PM-TRADE and the Training Technology Agency (TTA) within TRADOC.

The majority of the training resource availability data exists in written documents and records at the various TRADOC schools, TRADOC HQ, DA, and other elements of the Army. Portions of the data exist in electronic media as part of the Army Extension Training Information System (AETIS) and the Army Instructional Management System (AIMS). These two systems both contain training-related data bases that include training resource information. This data is related primarily to institutional training, however. Part of the development process

Table 1.

Summary of the training resource availability data base

| <u>DATA SOURCES</u> | <u>STRUCTURE</u> | <u>USER INPUTS</u> | <u>USER GUIDANCE</u> | <u>OUTPUT</u> |
|----------------------------|------------------|--------------------------------|--|-----------------------|
| TRADOC Schools | Training Setting | Data base dimension categories | Potential data sources | Training |
| Combat Development Centers | X | | | Resource Availability |
| TRADOC HQ | Time | | | Data Base |
| FORSCOM | X | | | |
| USAREUR | Resource Type | | | |
| Chief of Engineers | | | Current Limits for resource availability | |
| PM-TRADE | | | Projected changes in availability overtime | |
| TTA | | | | |
| AETIS | | | | |
| AIMS | | | | |

of the TEM will be the further specification of electronic data bases, agencies, documents, and potential POCs from which the user may obtain data related to training resource availability.

Structure. Immediately after activating the resource availability data base program, the user will be queried to provide the structure for the data base. The data base will be constructed as a three dimensional array with dimensions corresponding to:

- training setting
- time dimension
- types of training resources

Figure 4 provides an illustration of the data base structure with sample categories listed.

The training setting dimension has three default categories which are associated with different types of training resources. The default categories include:

- resident training
- on-the-job (garrison)
- tactical field training

The user will be queried to accept the default values, delete irrelevant settings, or further subdivide each of the settings to identify more specific training locations.

The time period dimension of the resource constraints data base will have a default value of 1 year increments based on the government's fiscal year calendar. The user must specify the beginning and ending fiscal years for the period of interest. If desired, the user may use calendar years rather than fiscal years.

The most complex dimension to be established in the data base will be the training resource type dimension. The major types of resources to be included as default values which have been identified to date include:

- Classrooms
- Furnishings
- Instructors
- Materiel System Requirements
- Non-materiel-System Equipment Requirements

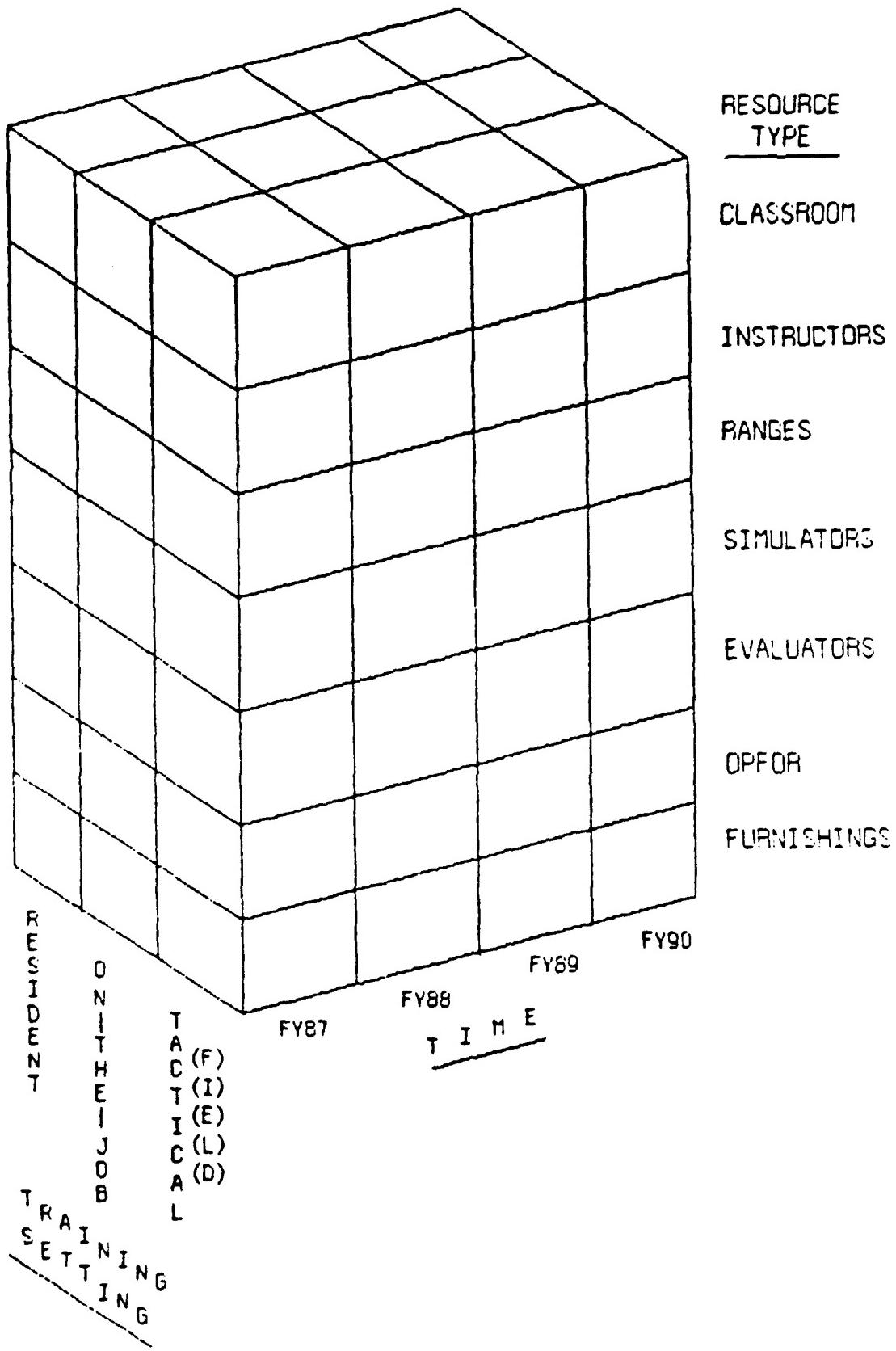


Figure 4. Training resource availability data base

- Range requirements
- Maneuver Areas
- Evaluators
- Simulation devices
- Ammunition
- Opposing Force (OPFOR)

The program will allow the user to:

- input additional types of training resources not included in the default categories
- subdivide categories such as instructors and classrooms
- to delete types of resources not relevant to the materiel system of interest

It is important to note, however, that help from the data base program regarding suggested sources of resource constraints data will be available only for the major resource types contained as default values in the program.

Once the user has selected the parameters to be used for each of the three dimensions of the constraints data base, the program will generate the user's data base structure. The program will then enter the next phase of the data base development process and begin prompting the user for resource constraints data for each cell of the data base.

User Input. The initial concept for the TCM was based on the premise that an initial resource availability data base would be developed at the time the TEM was developed. Experience gained in working with development of a model for early-on training analysis for the Army's Light Helicopter Family (LHX) program has led the authors to conclude that training resource constraints data must be input by the user specifically for the materiel system of interest. This allows the data base to be tailored to the needs of the user and avoids the need for a central data base manager who must constantly update the TEM data bases.

The user will be prompted to complete each cell of the three dimensional data base. The entry in each cell will represent the availability for a particular type of training resource, in a specified training setting, at a specific point in time. The initial data entry prompt will be for the input of the extant limit of a training resource category. This prompt will differ across resource categories. For example, if the user selects the firing range class as a relevant resource the program may prompt

the user for number, size, and time available for training on the ranges. The prompt for the maneuver area is likely to include input values for area available and time available while the prompt for the instructor resource will probably ask only for the number of instructors available.

If the user lacks data to complete a cell in the data base he may:

- move to another cell in the data base and add the data for the cell later
- query the program for suggested data sources
- input a "data not available" entry
- identify the cell as not applicable

After completing the input for a prompt for the extant resource limit, the user will be prompted to input anticipated changes in resource levels during the time period of interest. The user may choose:

- a steady state of the resource limit (no change)
- input specific absolute increases/decreases by year
- input a total percentage increase/decrease across the time period of interest
- input yearly percentage increases/decreases

If the user enters a single percentage change of resources value for the entire period of interest, the change will be distributed evenly across the entire time period. It should be noted that a user may enter a "zero" availability value for the initial extant resource limit prompt and then increase the availability of resources above zero during later time periods of interest. Regardless of the format of user entry, each entry stored in the matrix will be expressed in terms of the absolute value of the resource availability.

Guidance to users on data sources. It is anticipated that TEM users may not initially possess all of the information required to complete the training constraints data base. Thus, one function of the resource constraints data base element of the TCM is to provide guidance to the user on how to obtain such data. In its final form, the program will direct the user to types of documents, electronic data bases, or agency points of contact. The potential sources of data and samples of the type

of training resource data available from each source identified to date include:

- Proponent Combat Development Centers
 - course hours
 - instructor projections
 - materiel system availability
- TRADOC Schools
 - classrooms
 - non-materiel equipment
 - furnishings
 - instructors
- TRADOC Headquarters
 - instructor projections
 - facility projections
 - major equipment projections
- PM-TRADE
 - new simulation technology
- FORSCOM, USAREUR, etc.
 - combat simulation training devices
 - evaluators
 - OPFOR
 - ranges
 - maneuver areas
 - ammunition
- Chief of Engineers (DA)
 - maneuver areas
 - major training facilities
 - ranges
- AETIS and AIMS data bases
 - course hours
 - equipment

Output. When the user has completed running the program for the resource availability data base, he will have constructed a detailed data base indicating maximum limits for a variety of training resources. Furthermore, the data base will provide information regarding expected changes in these resource limits over the time period of interest to the user. This data base will be particularly important when used in conjunction with the training resource consumption matrix which will be generated as part of the analytic process used by the TAM to estimate the "most likely training" for the materiel system.

Predecessor Training System Data Bases

Given the evolutionary nature of Army training, it is essential that the TEM users conduct a thorough evaluation of the training programs for predecessor systems. The second major element of the TCM is composed of data collection guidance and data base development programs to construct two predecessor training system data bases. This element of the TCM has three major components:

- A user training program
- A data base development program for identifying predecessor training system resource requirements
- A data base development program for predecessor training system problems

Each of these components is discussed in more detail below.

User Data Collection Training. The first component of the predecessor system data base element of the TCM will be a user training program. The program will provide:

- information on potential data sources
- questions to guide data collection
- sample data collection forms

The purpose of the on-line training program is to aid the user in obtaining predecessor training system data in the most time efficient manner. The potential data sources for development of the two predecessor training system data bases are identified later in this section. The training program will provide the user with a plan of attack and the tools needed to collect and evaluate predecessor training system documentation. The sample questions provided in the training program will help the user:

- identify the most likely sources of data
- identify the categories to be used in structuring the predecessor system data bases
- suggest efficient ways of extracting and summarizing data from existing documentation

The training program will provide the user with sample data collection or data summary forms which may be used to summarize data in predecessor training system documents. The program will also aid the user in constructing customized resource requirement data collection forms to be used with the predecessor systems of interest. The content of the program will be based on lessons

learned by the current research team from previous experience in development of predecessor training system data bases used for MPT analyses.

Predecessor Resource Requirements Data Base Development

The predecessor resource requirements data base element of the TCM will function in a manner similar to the training resource constraints data base described previously. Table 2 summarizes the data sources, structure, user inputs, and output for the predecessor resource requirements data base. Each major element of the data base is discussed in detail below.

Data Sources. Typically, a substantial amount of documentation on predecessor training system resource requirements exists at various locations throughout the Army. The challenge is usually that of collecting and digesting the information. Potential sources of data on predecessor training system resource requirements which have been used by the current research team to develop predecessor training system requirements data bases include:

- POIs for courses for relevant MOS
- ICTPs for predecessor systems
- Unit Training Plans
- ARTEPS
- Soldier Manuals

Additional data related to predecessor training system requirements may also exist on a variety of computerized training management and information systems. The Army Extension Training Information System (AETIS) and the Army Instructional Management System (AIMS) are potential sources of such data. The structure of the AIMS is still under development and may include a variety of data bases which can be used in future analyses of training systems. It should be noted, however, that the information contained in both systems is related primarily to training in the TRADOC school system.

Structure. Like the resource availability data base, the user will be prompted to define categories on the two dimensions of the predecessor resource requirements data base. The two dimensions of the current data base are type of training resource and phase or element of the predecessor training system.

The "type of training resource" dimension in the current data base is identical to the training resource category

Table 2.
Summary of the predecessor resource requirements data base

| <u>DATA SOURCES</u> | <u>STRUCTURE</u> | <u>USER INPUTS</u> | <u>OUTPUT</u> |
|---------------------|------------------|---|---------------|
| Relevant PDIs | Resource Type | Data base | Predecessor |
| ICTPs | X | dimension | Resource |
| Unit Training Plans | Element of | categories | Requirements |
| ARTEPs | Training Program | | Data Base |
| Soldier Manuals | | Training Resources for various elements of the predecessor training program | |

dimension the user defined in the resource availability data base. The default categories for the dimension are:

- Classrooms
- Furnishings
- Instructors
- Materiel System Requirements
- Non-materiel-System Equipment Requirements
- Range requirements
- Maneuver Areas
- Evaluators
- Simulation devices
- Ammunition
- Opposing Force (OPFOR)

The user may delete, add, or subdivide resource categories as described for the previous data base. The user should select the same resource categories on this dimension of the predecessor resource requirements data base as are used in the resource availability data base.

The second dimension representing the phase or element of the predecessor training system is unique to the current data base. This dimension requires the user to define new categories. The user will be prompted to define relevant phases or segments of three types of training for the predecessor system including:

- Institutional training courses
- Unit training in garrison
- Capstone tactical training events such as NTC

The user will have received information concerning how to define such phases of training in the user training program. While the institutional courses and capstone tactical training events are self-explanatory, the unit training categories are somewhat more difficult to define. In development of predecessor training system requirement data base for research on the LHX, the phases of predecessor unit training included in the data base were:

- new equipment training (NET)

- individual/crew training
- company/unit training
- gunnery training
- battalion training
- ARTEP

User input. Once the structure for the data base has been defined, the user will be prompted to complete each cell of the matrix. The user entries will be absolute values of the resources required to implement each phase of the predecessor training system. The data will represent resources consumed during a single cycle of a specific phase of the predecessor system training program rather than total resources consumed. There is no projection of resource requirements over time for the predecessor training requirements data base. The resource requirements are calculated for a single training cycle.

Output. Figure 5 provides an illustration of the output structure of a sample predecessor resource requirements data base. The predecessor resource requirements data base will be used in conjunction with output from the TAM to construct a resource requirements matrix for the overall training program for the material system being evaluated by the TEM user. Greater detail on the use of this data base will be described in the description of the TAM.

Predecessor Training System Problems

The data base for the predecessor training system problems represents a qualitative data base rather than a quantitative data base. The construction of the data base will be interactive as was the case with the previous data bases discussed. Table 3 summarizes the data sources, structure, user inputs, and output for the predecessor training system problem data base. Each element in the table is described below.

Data Sources. There are fewer written sources of information for predecessor training system problems than for the other data bases included in the TCM. Potential Sources for data on predecessor training system problems identified to date include:

- Post-fielding CTEAs
- MAAs conducted after fielding of the system
- Interviews with SMEs

Phases of Training

| RESOURCES | Institutional | | Unit Training | | CAPSTONE Technical | | |
|------------------|-----------------|-----|-----------------|----------------|--------------------|-------|-----|
| | Resident Course | NET | Individual Crew | Company / Unit | Bn | ARTEP | NTC |
| Classrooms | | | | | | | |
| Instructors | | | | | | | |
| Matériel Systems | | | | | | | |
| Ranges | | | | | | | |
| Simulators | | | | | | | |
| Evaluators | | | | | | | |

Figure 5. Sample predecessor resource requirements data base structure

Table 3.
Summary of the predecessor training system problem data base

| <u>DATA SOURCES</u> | <u>STRUCTURE</u> | <u>USER INPUTS</u> | <u>OUTPUT</u> |
|---------------------|------------------|------------------------------|-------------------------------------|
| Post-fielding CTEAS | Text | Reference of Problem Area | Listing of user prompt questions |
| MAAs | Files | Presence of Problem | Structured data base reports |
| SME Interviews | | Problem Description | |
| | | Data Source | |

The identification of additional sources of potential data for this data base represents a task which must be completed in later phases of development of the TEM.

Structure. The structure of the current data base is not specified apriori by the user as was the case with the previous data bases. Rather, the data base will be structured as a series of text files to be searched, sorted, and printed by a data base program. The size of the data base will depend on the number of questions answered by the user and the length of the answers provided. The underlying file structure of the data base includes four data fields corresponding to the user prompt questions for each potential problem area. The data fields include:

- relevance of the problem area
- indication of presence of problem
- description of the problem
- source of data describing the problem

The data base will have a minimum default number of text files corresponding to the number of problem area questions used as user prompts. The data base program will be structured to allow the user to enter additional problem areas with their associated data.

User Input. The user will be prompted with a set of questions regarding potential problem areas which may have been identified for the predecessor system. For each potential problem area, the user will input:

- Whether the problem area is relevant to the predecessor system
- Whether the presence of a problem in that area was identified (if the problem area is relevant)
- A short description of the problem if one was identified to include as much quantitative data as possible
- Notation of the data source

The utility of the data base will, of course, depend heavily on the questions asked of the user. Given the emphasis of the current effort on providing interface designers with potentially useful data, many of the questions will be constructed to query the user concerning "training problems" which might be related to design problems with the predecessor system. Potential areas for questions include:

- Negative transfer of training effects

- Training errors or accidents due to design problems
- Crew training problems due to limited communication or difficult positions
- Unit training problems in movement formation due to limited visibility, etc

Output. The predecessor training system data base development program will include an option to print a listing of the user prompt questions. This listing of questions may be used to develop data collection instruments in the form of surveys or interview protocols to be used with SMEs who have conducted extensive training with the predecessor system.

The predecessor training system problem data base will be used with the FIM to generate structured qualitative reports for interface designers. The data base will have key word and key phrase search and sort capabilities and provide the data source citations required to form an audit trail to seek more information regarding the relevance of the predecessor system problem to the materiel system of interest to the user of the TEM output.

New Training Technology Constraints

A major factor which may cause a change in a new system's training program from that of predecessor training systems is the availability of new training technology. It must be recognized that a number of factors will impact on the availability of such technology including biases of the proponent schools in which training will occur.

The purpose of the third major element of the TCM is to identify factors which might limit the use of new training methods or technologies for the emerging materiel system. For the purposes of estimating the "most likely training" program, a new training technology or method is defined as a training method or technology which has never been applied in training for predecessor systems. While the technology may have existed for some time, it will be considered as new for the training system under analysis.

Table 4 summarizes the data sources, structure, user input, and output of the technology constraints data base. The development of the technology constraints data base will be accomplished in three phases as listed:

- Identification of potential new training methods and technologies
- User response to technology availability questions

Table 4.
Summary of the new technology constraints data base

| <u>DATA SOURCES</u> | <u>STRUCTURE</u> | <u>USER INPUTS</u> | <u>OUTPUT</u> |
|---------------------|-------------------------------|---|--|
| TAM | List of Potential | Response to Questions on availability and acceptance of technology or methods | List of new training technologies or methods that are likely to be used for new system |
| PM-TRADE | Training | | |
| TTA | Methods or Technologies | | |

- Identification of new training methods and technologies to be considered as "available" for the new materiel system training program

The three phases of the data base program described above correspond roughly to development of the data base structure, user input, and the data base output functions. The potential sources of data to be used for this data base and the other major elements of the data base are described below.

• Potential Data Sources. The identification of new training methods and technologies, as defined in the context of this data base, will require two types of information. The first type of data sources are those providing information about the predecessor training system. These data sources are identical to the sources used for the predecessor training resource requirements data based described previously.

The second type of data sources required are those related to potential training methods and technologies which have not been used with predecessor systems. The TAM provides a variety of potential training methods to the user and will be a principal source of data for potential instructional methods. Information regarding the latest simulators and other high technology training applications can be obtained by the user from PM-TRADE or from the TTA in TRADOC.

Structure. As noted above, the first step in the development of the current data base will involve identification of potential training technologies which have not been used in predecessor training systems. By comparing information from the data sources listed above, the user can compile a list of potential new training methods and technologies. This list can be compiled manually or a routine in the data base program can be used to prompt the user for a variety of potential training technologies and methods. If the prompts are used, the user will simply indicate if the training method had been used in predecessor systems. The user will then add any additional training methods identified during his data collection effort. Alternatively, the user may enter his own list of training methods and technologies, bypassing the prompts entirely. In either case, the list of new potential training methods and technology will establish the structure for the remainder of the data base. The data base program will prompt the user to answer a series of questions for each method or technology included in the list entered in this phase of the program.

User Input. Once the user has identified the potential training methods and technologies not previously used in predecessor system training, the data base program will prompt the user to answer a series of questions concerning each training

method or technology. The questions to be answered by the user for this data base are listed below.

1. Does the proponent school or units receiving the new system currently use the training method or technology with other systems? (YES OR NO)
2. Do other schools or units in the Army currently use the training method or technology? (YES OR NO)
3. Are the proponent school or units receiving the new system currently authorized and funded to purchase or develop the new training methods or technology? (YES OR NO)
4. Have the schools or units requested the funds or other resources required to purchase or develop the technology or training method? (YES or NO)
5. Is the training method or technology currently available in the commercial market? (YES OR NO)
6. If the new technology or method is not available in the Army or commercial market, what is the current stage of development of the technology:
 - a. In production
 - b. Prototype testing
 - c. Prototype development
 - d. Experimental testing of method
 - e. Basic research and development
 - f. Concept development phase.
7. If the training technology or method were available at no cost to the proponent school or units receiving the new materiel system what is your estimate of the probability that they would use the technology or method in their training program? (enter a probability value from .00 to 1.00)

Output. The data base program will "score" each question and calculate a total score scaled to reflect the "probability of use" for each new training technology or method in the data base. The most appropriate "cut-off" score for a training method or technology will be determined during the development phase of the TEM. Based on this cut-off score, the technology constraints program will output a list of "likely new training technologies or methods" which should be considered as feasible for use in the training program for the materiel system of interest. New training technologies and methods which are not included in the list will be excluded from consideration in development of the "most likely training program" constructed using the TAM.

Additional Training Constraint Data Bases

In addition to the three major elements described above, the TCM will guide the user through an examination of one, and possibly two, additional sets of constraints on the "most likely" training program for the materiel system of interest. These two additional sets of constraints are briefly discussed below.

Manpower and Personnel Constraints

Product 3 of the MPT-Estimation Tools will provide a lower bound estimate of the target audience for the materiel system of interest. The TCM will include a data base of this output. This information will be used by SMEs during analyses conducted using the TAM. An additional source of manpower and personnel constraints data which is relevant for the purposes of estimating the most likely training program will be an estimate of the number of trainees who will be in the active versus reserve components of the Army. The TEM user will be guided to examine the materiel system distribution plan to derive an estimate of the number of reserve personnel who must be trained for the system.

Reserve Component Training Constraints

While the SOW does not address the issue of active vs. reserve personnel, the increasing role which the reserve components of the Army are expected to play in the event of war, suggests that this may be a factor which must be considered. This reserve component issue is particularly important in providing the interface designer and training system developer with an accurate estimate of the most likely training to be received by personnel using the system. Reserve personnel often spend less time in resident training, have "institutional training" distributed over longer time periods, train less frequently, and experience other differences in training compared to active component personnel in the Army. This difference in training experience is particularly true for hands-on training and for maintenance training of major systems.

The data bases of the TCM may be developed for both active and reserve components to provide the TEM user with the data required for comparison of the most likely training systems which will evolve for the personnel in the two components. This information may be critical if reserve personnel are expected to man the system during periods of war and if the most likely training systems for the active and reserve component appear to differ substantially.

Summary of the TCM

The purpose of the TCM is to develop a set of training constraints data bases which will be used as input for the Training Analysis Module (TAM) and to generate reports relevant to the PTEA. The TCM consists of three major elements including:

- Development of a training resource constraints data base
- Development of predecessor training system resource requirements and training system problem data bases
- Identification of constraints on the application of new training technology and methods for the emerging materiel system training program

The TCM uses computer programs to guide the user through the development of the data base structure and to input data for each of the functions identified above. The programs for each of the three functions provide some form of help to the user in identifying potential sources of information needed to development the data base.

The completion of the three major functions of the TCM results in the development of four data bases. The data bases include:

- Training resource constraints
- Predecessor system training resource requirements
- Predecessor training system problems
- Training technology constraints

The Training Analysis Module

Objective

As noted in previous sections, the Training Estimation Methodology is being developed to support the conduct of PTEAs. In this capacity, the TEM must address: (1) training constraints, (2) potential training problem areas, and (3) the development of the training concept for an emerging materiel system. TRADOC Regulation 350-4, The TRADOC Training Effectiveness Analysis (TEA) System, states that the training concept is to delineate the following aspects of an emerging system's training program: (1) what is to be trained; (2) who is to be trained; and (3) the "how, when, and where" of training. The Constraints module described in the previous section addresses training constraints and problem areas. Training concept development is the objective of the Analysis module, or TAM.

The training concept for an emerging system outlines the broad architecture of the associated training program. Later, more detailed training analysis and design activities carried out as part of the CTEA process will use the training concept as a point of departure for the definition of MOS-specific training requirements. In our view, a training system is a process structured to impart necessary job skills to a specified target population. In developing the TAM, we are attempting to formulate a methodology that will assist Army training development: (1) early-on thinking about training as a system in which a complex network of skills is acquired in a progressive fashion using cost-effective means, and (2) formally defining the scope and general nature of the most suitable system for meeting this end.

When the output of the TAM is analyzed within the context of the constraints identified in the TCM, the output represents the "most likely" training program to emerge for the materiel system of interest. This information will be of greatest interest to the materiel designers seeking an estimate of the training program which will accompany the system they design.

The TAM Concept

A graphic overview of the TAM is presented as Figure 6. From Figure 6, input to the TAM consists of:

- The output from Product 1:
 - Behavioral elements (i.e., tasks)
 - Conditions of performance
 - Performance standards
- System Concept(s): Ideas concerning what the proponent wants to acquire
- Information regarding predecessor or referent systems
- Output from the Constraints module:
 - The constraints boundary
 - Training problems on predecessor or referent systems
- Output from Product 3: A Target Audience Description

The collective output from Product 1 is used to structure a description of the composite performance environment of the target system: doctrine, tactics, performance demands (tasks, conditions, and standards), maintenance and support concepts, and the like. All of this information serves as the data base for the training-related analyses to follow.

The TAM is exercised in five elements, listed as follows:

- Task Identification

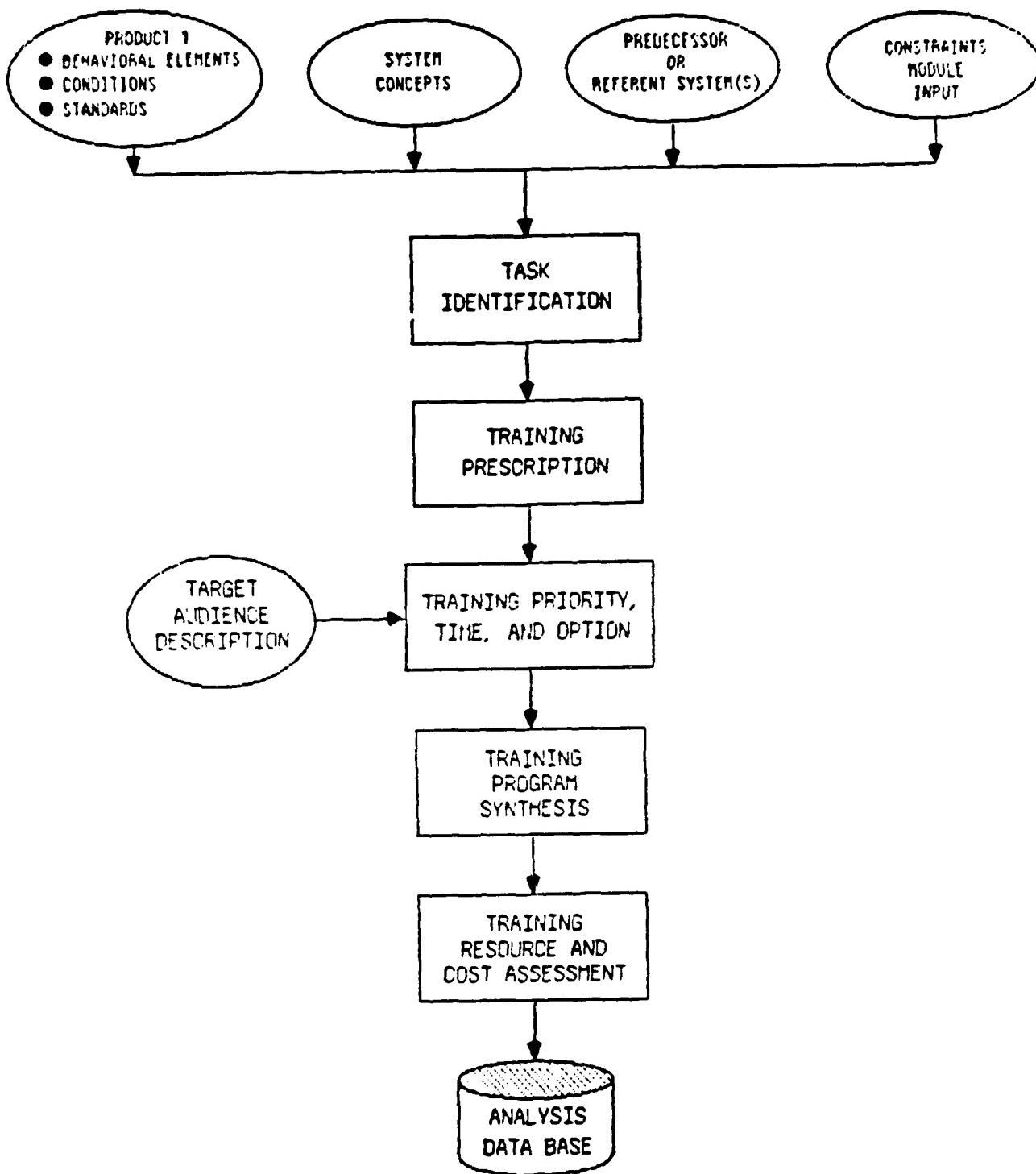


Figure 6. The training analysis module.

- Training Prescription
- Training Priority, Time, and Option
- Training Program Synthesis
- Training Resource and Constraints Assessment

The first four TAM elements are similar to the activities performed as part of a conventional, detailed training requirements analysis, but are intended to function at a generic as opposed to a specific level. Early-on during system development, specific information regarding materiel items and employment concepts is often not available. Hence, to be useful to training developers during concept exploration, the TAM must be capable of processing generic information.

The first four elements comprising the TAM are adapted from similar procedures developed for the Training Developers Decision Aid (TDDA) Versions 1 and 2 (Pieper, Guard, Michael, & Kordek, 1978; Pieper, Elliott, & Hawley, 1979; Hawley, 1979; and Frederickson, Hawley, & Whitmore, 1983). Both previous versions of the TDDA were developed to assist Army training developers in structuring training for fielded weapons systems. In the present application, the TDDA methods have been generalized for use with concept-level (i.e., pre-prototype stage) systems.

The fifth element of the TAM, the resource and constraints assessment represents a deviation from earlier versions of the TDDA. While the first four elements of the TAM produce information regarding an "optimal" training program, the fifth element will utilize data from the TCM to modify the "optimal" training program to fit projected resource and technology constraints. The results obtained from exercising the fifth element is the TEM's prediction of the "most likely training" program for the materiel system being evaluated. This prediction reflects the impact of the predecessor training system, unique training requirements identified for the new system, and constraint factors which impact on the training system. Each element comprising the Analysis module is now described in turn.

Task Identification

As noted previously, one of the inputs to the TAM (from Product 1) consists of a set of target behavioral elements (i.e., tasks) along with performance standards and a listing of the conditions under which a job will be performed. The term "behavioral elements" is used here instead of "tasks" because we are not certain at this time of the precise nature of the output from Product 1. Regardless of the form of the output from Product 1, it is likely that some amount of "polishing" will have to be performed on the resulting output prior to using it in the Analysis module. The objective of the Task Identification

element is to serve an interface between Product 1 and the TAM; it will be tailored to serve in this role whatever the eventual form of the output from Product 1.

As the first step in exercising the TAM, the behavioral elements received from Product 1 are recast as task statements suitable for use with the module. This consists, first, of mapping the behavioral elements from Product 1 onto a set of Task Action Verbs that are conformable with other TAM elements. Table 5 presents a set of representative Task Action Verbs used in the TAM. A complete listing of Task Action Verbs is presented in Appendix A. It should be noted that mapping behavioral elements onto Task Action Verbs may require the user to parse the output from Product 1 into smaller behavioral units. That is, function-like statements may have to be broken down into sub-functions; and sub-function-like statements may have to be broken down into behavioral elements resembling tasks.

Table 5.

Representative TAM task action verbs

| <u>Verb</u> | <u>Verb</u> |
|-------------|----------------|
| Abide by | Apply |
| Accept | Arrange |
| Accommodate | Assemble (Dis) |
| Acquire | Assign |
| Activate | Associate |
| Adapt | Attend |
| Adjust | Calculate |
| Adjust to | Catalogue |
| Advise | Categorize |
| Aim | Characterize |
| Align | Check |
| Allocate | Choose |
| Analyze | Cite |
| Answer | Classify |
| Anticipate | Clean |

Once appropriate Task Action Verbs have been selected, the next step in creating task statements involves determining system and support (i.e., stand-alone electronic test equipment, special tools, etc.) equipment items. System and support equipment items are determined on the basis of predecessor or referent system configurations (i.e., from a BCS). The completed task statement then consists of a Task Action Verb, an item of system equipment that is acted on, any support equipment used, the performance standard, and conditions of performance. Task statements are also categorized according to whether they pertain to operations, maintenance, or support. All of the steps comprising the Task Identification element of the TAM are shown graphically in Figure 7.

Training Prescription

The second element comprising the TAM involves the specification of a training prescription for each task statement. Task training prescriptions are generated through a logical and analytical process that results in the specification of five items of information:

- Learning Algorithm
- Stimulus Medium
- Response Acceptance Mechanism
- Method of Instruction
- Learning Setting

Each of the five aspects of the training prescription is described in the subsections to follows.

Learning algorithm. The Task Action Verb is used to uniquely specify one of 12 learning algorithms. A learning algorithm is a model instructional approach which is appropriate for tasks of a given type. As an example of a learning algorithm, Figure 8 presents the algorithm for tasks involving "Identifying Symbols." The learning algorithms proposed for the TAM are adapted from those used in Version 1 of the TDDA, which are derived from algorithms presented in TAEG (Training Analysis and Evaluation Group) Reports 16 and 23 (Braby, Henry, Parrish, & Swope, 1975; Aagard & Braby, 1976). These learning algorithms are listed and defined as follows:

1. Identifying Symbols. Recognizing and interpreting graphic characters such as those used in engineering drawing, maps, and status boards.
2. Verbal Chaining. Recalling and applying previously learned facts and principles in a job setting.

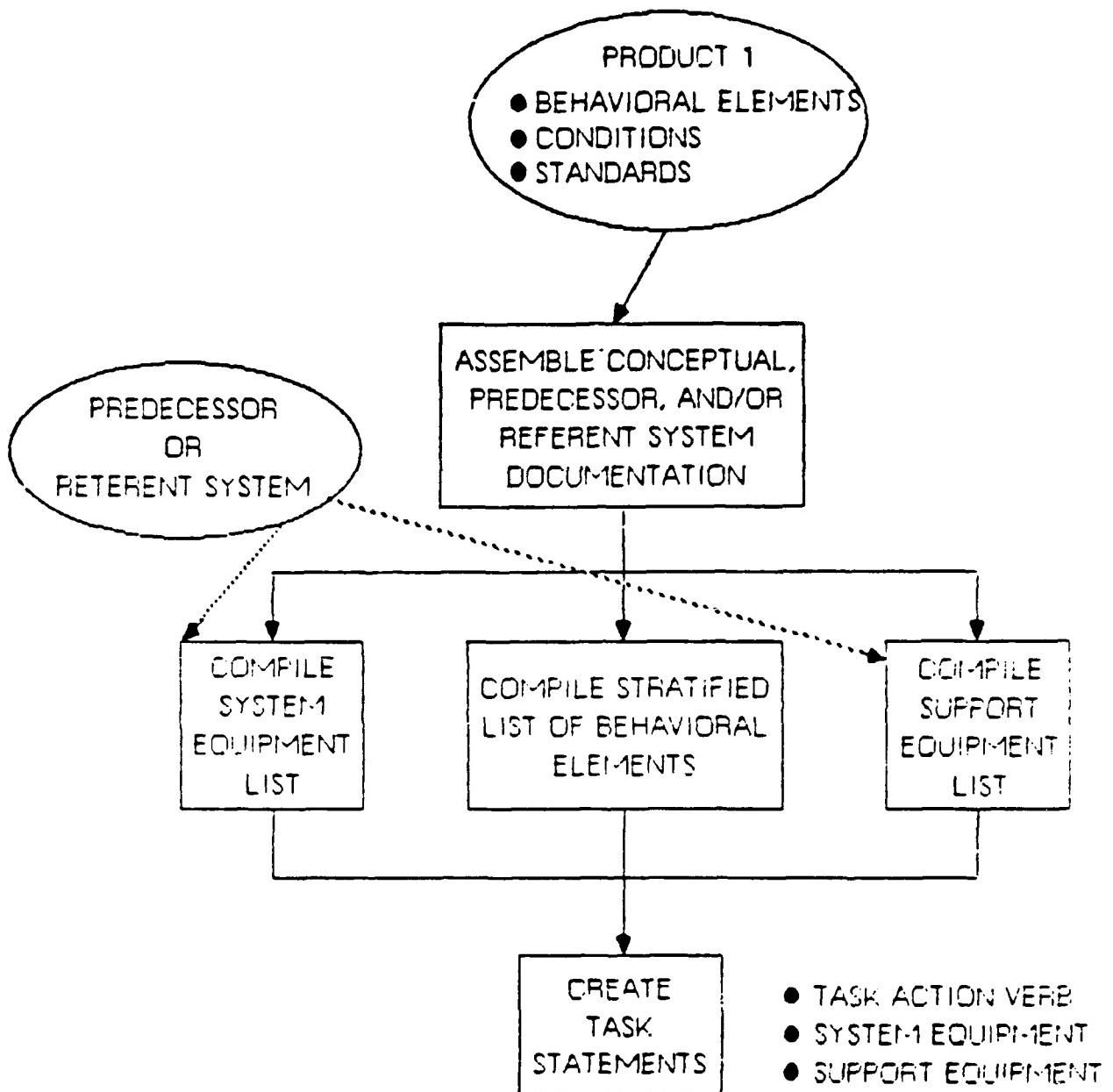


Figure 7. Task identification.

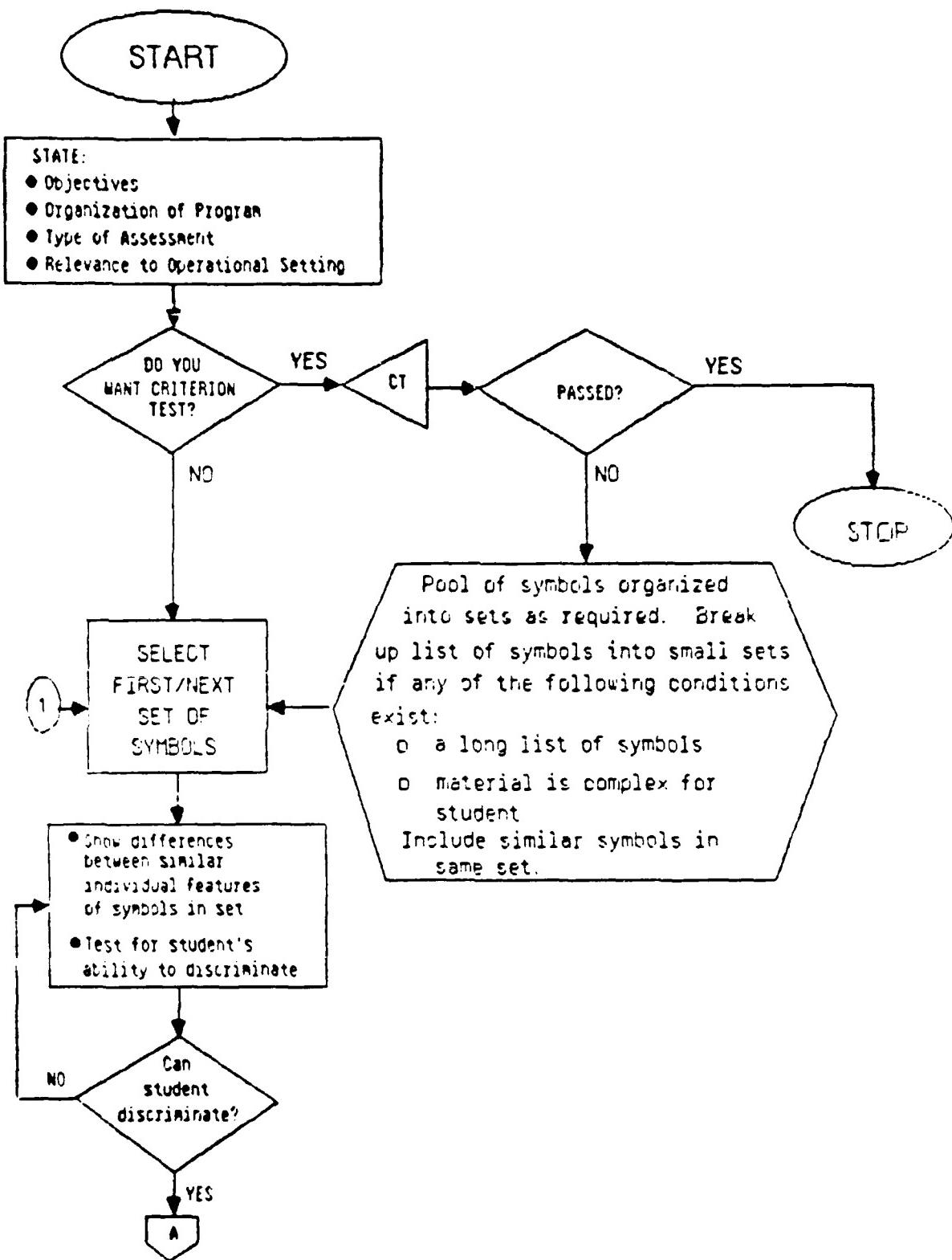


Figure 8. Learning algorithm for identifying symbols.
(adapted from Aagard & Braby, 1976)

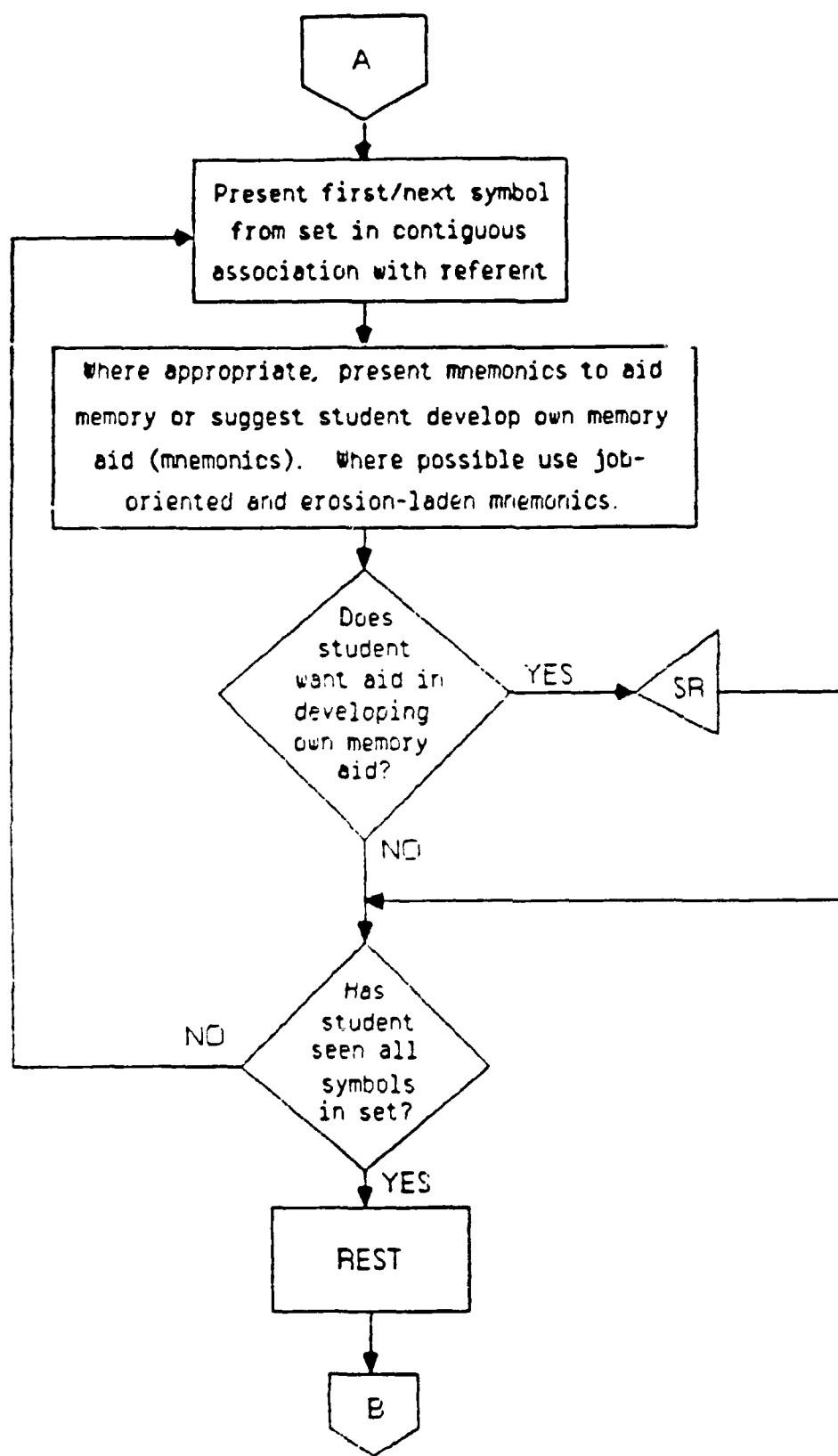


Figure 8. (continued)

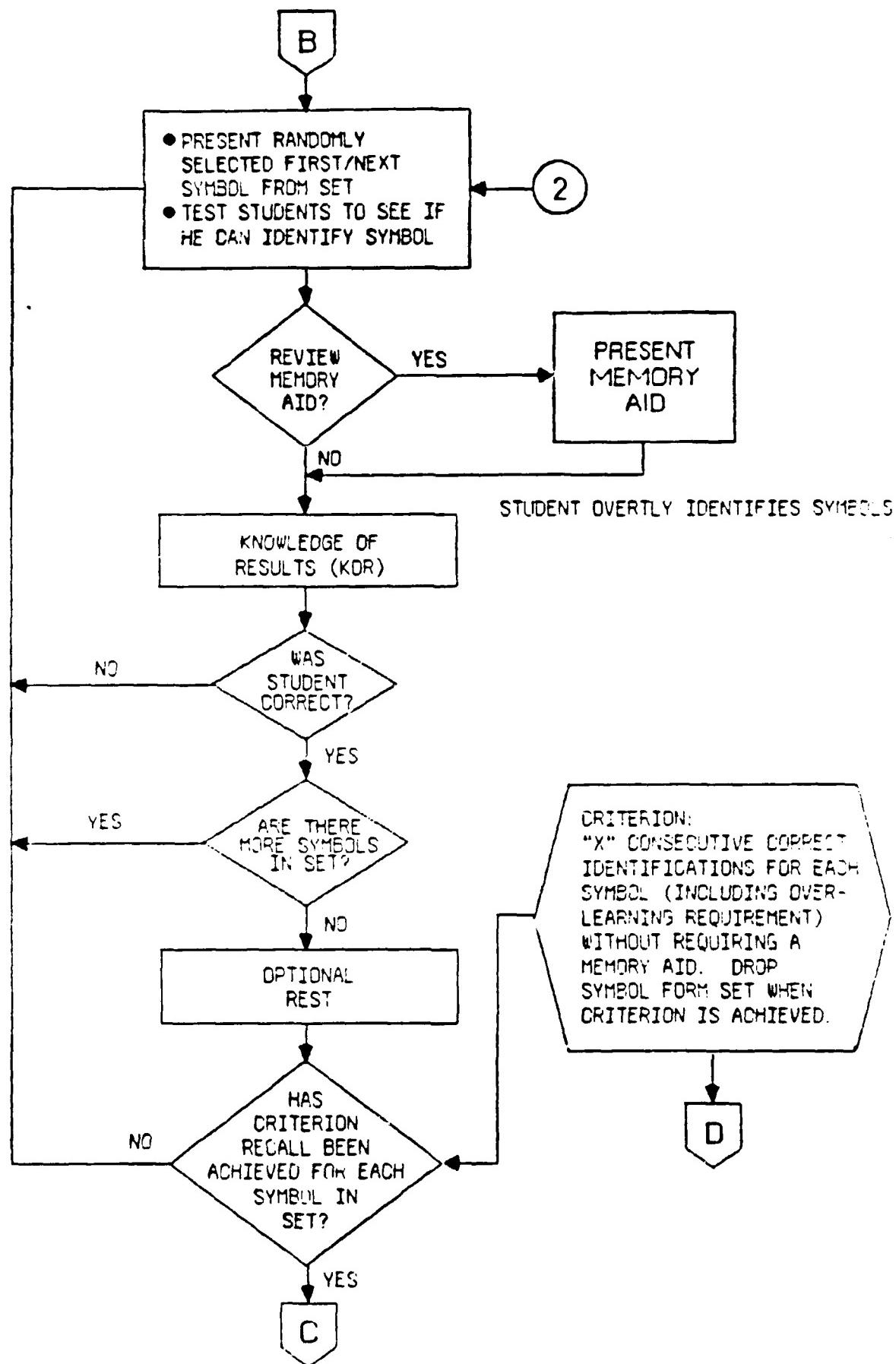


Figure 8. (continued)

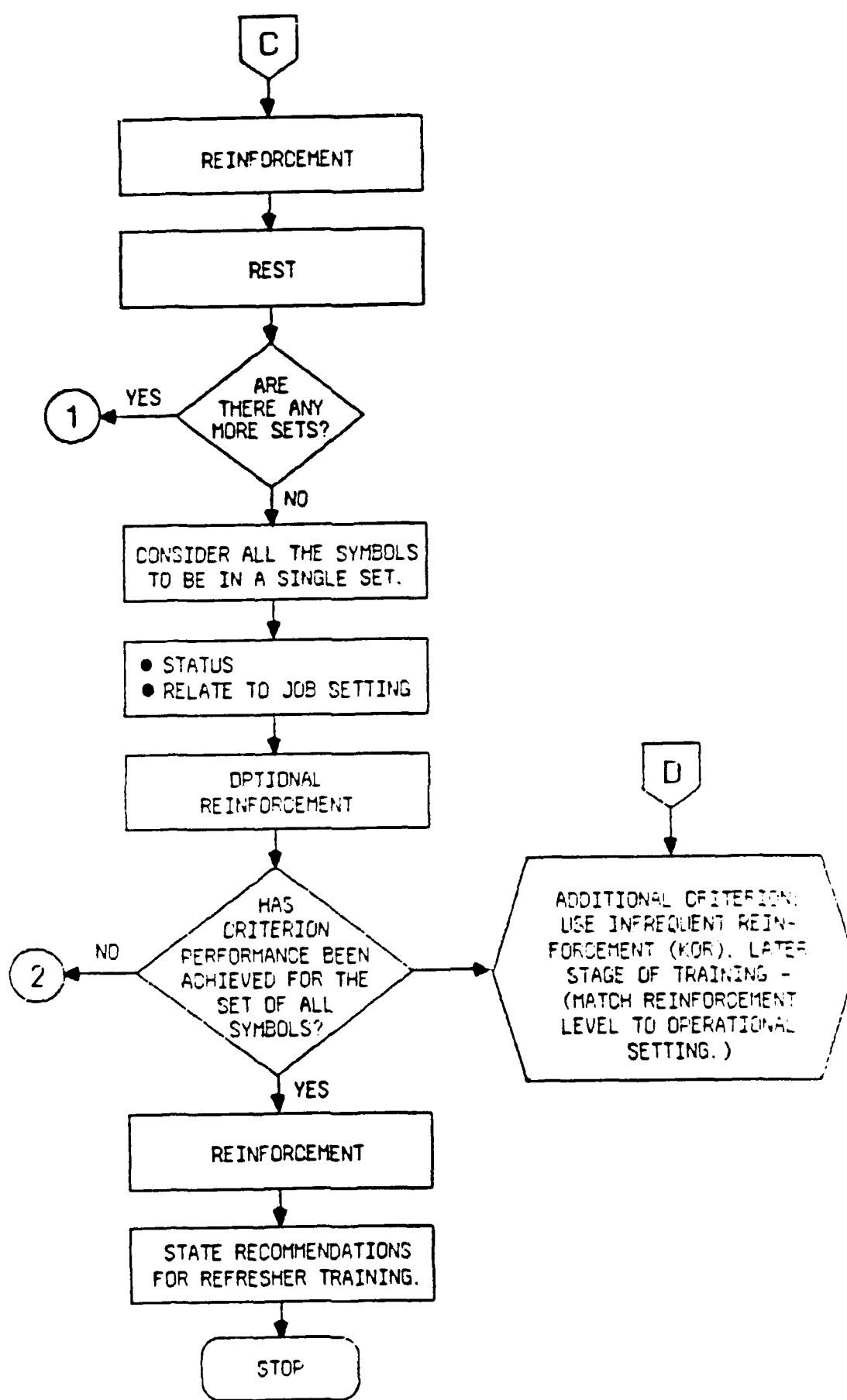


Figure 8. (continued)

3. Rule Using. The acquisition and application of established practices or fixed principles (rules) that serve as guides in selecting courses of action.

4. Classifying. Assigning names to detected symbols based on identifiable characteristics.

5. Decision Making. The application of a specific decision model thought to be useful in diagnosing equipment malfunctions, choosing tactics, or in planning where several alternatives must be considered.

6. Problem Solving. Evaluating and integrating information from a number of sources to effect a solution to a problem.

7. Gross Motor Skills. Repetitive motor acts involving chaining of movements and a low level of attention by a skillful performer.

8. Motor Chaining. Carrying out routinized activities, executed as standard operating procedures, in some predetermined sequence.

9. Steering, Guiding, and Continuous Movement. Continuous physical responses to a constantly moving visual reference.

10. Communicating. A conversation between people in which standardized message formats are employed.

11. Monitoring. Becoming alert to the presence of a signal that could be of special interest in the performance of a job or mission.

12. Attitudes. Learning, recognizing, and recalling information needed to function in an operational setting.

Appendix A lists each Task Action Verb along with its associated learning algorithm.

Stimulus Medium. The stimulus medium prescribes the modality or mechanism through which task stimuli are to be presented to trainees. In characterizing the stimulus medium, TEM users first identify the general class of stimuli that will be encountered in the job environment. This is done to insure as much job-related fidelity as possible in the stimulus presentation during training. The general classes of stimuli proposed for the TAM are the following:

- Verbal. Letters or numbers are used by the job holder in performing the task
- Audio. Sounds are important in doing a task

- Audio/Visual. Sounds and visual observations are important in performing a task
- Visual. Visual observations are required to do a task
- Tactile. The job holder is required to use his sense of touch in the performance of a task

In the event that more than one stimulus class is applicable, users should select all relevant classes and then process the logical union of all ensuing results.

The user next describes selected characteristics of the task stimulus in sufficient detail to discriminate between presentation media appropriate for various stimulus classes. Stimulus characterization items are listed as follows:

- Are stimuli in color?
- Are stimuli equipment indicators?
- Are audio stimuli voice only?
- Are stimuli visually distinct -- not obscured or overshadowed by peripheral stimuli?
- Are movements continuous as opposed to discrete (i.e., "on" or "off")?
- Are verbal stimuli audio?
- Are stimuli frequently changed or updated?
- Are stimuli three-dimensional (i.e., solid objects)?
- Are many ambient sounds present?
- Are ambient sounds random as opposed to cyclic or periodic?
- Are audio stimuli equipment generated?
- Do the stimuli move?
- Will performing the task wrong result in damage to system equipment?
- Is the system equipment expected to be operational at least 75% of the time?
- Is the task a maintenance or support task (as opposed to an operator task)?

Responses to the stimulus characterization items are used to select the most appropriate media to present stimulus characteristics to trainees. The logic of the TAM media selection process is illustrated in Appendix B, Figures B-1 through B-5. The following stimulus presentation media are currently included in the TAM:

- Audio tape
- Printed material
- Microform
- Mockup
- Movie
- Actual Equipment
- Silent film strip
- Silent slides
- Simulator
- Sound film strip
- Sound slides
- Television

Additional stimuli presentation media will be added to the TAM during the development phase of the current effort. The media to be added included presentation through micro-computers (CRT) and computer interactive video disc (CIVD).

Response acceptance mechanism. The training prescription process continues with the identification of a response acceptance mechanism--the manner in which a trainee's responses to the learning situation are accepted and evaluated and feedback provided. As with the stimulus medium, the user first identifies the general class of response involved, and then proceeds to answer a series of questions that further characterize the nature of the response. The general classes of responses employed in the TAM are given as follows:

- Equipment Manipulation. The job holder must physically manipulate equipment while performing a task.
- Voice. The job holder is required to use his or her voice while performing a task.
- Written. The job holder is required to record or write while performing a task.

- Body Movement. The job holder uses specified body movements in the performance of a task.

The items used to further characterize trainee responses are listed as follows:

- Is the task a maintenance or support task (i.e., one that requires access to the interior of the system)?
- Are equipment manipulations discrete as opposed to continuous?
- Are equipment control displays nonlinear?
- Will performing the task wrong result in damage to system equipment?
- Is the system equipment operational at least 75% of the time?
- Does the response consist mainly of knowing control or display names and locations?
- Does the student respond by giving instructions or orders to a group?
- Does the response require interactions with others?
- Does the job performer evaluate his or her own response?
- Is the response a mix of selected and constructed?
- Is the response selected, or mostly selected?
- Is the response written on a form?
- Does the job performer respond to voice instructions?
- Does the response consist of a coordinated group performance?

Response acceptance mechanisms proposed for the TAM are listed below. The logic of selecting response acceptance mechanisms on the basis of user input is illustrated in Appendix B, Figures B-6 through B-10.

- Audio tape recorder
- Printed material
- Group instructor
- Mockup

- Actual equipment
- Simulator
- Teaching machine
- Tutor
- Video recorder

The teaching machine response acceptance mechanism will be modified during the development phase in the current effort to represent a computer terminal or micro-computer. CIVD will also be added to the list during the development phase.

Method of Instruction. The stimulus medium and the response acceptance mechanism are next used to select a method of instruction. This selection process is basically one of identifying training methods that support the requirements imposed by both the stimulus presentation medium and the response acceptance mechanism, and then selecting the optimum method or methods. Optimality, in this context, is determined by characterizing both the stimulus presentation medium and the response acceptance mechanism in terms of several additional factors and then tallying the number of "matches" for each method. The method having the largest number of such matches is selected.

Factors used in the TAM to further characterize the stimulus presentation medium are listed as follows:

- Pacing Controller. The mechanism controlling the speed of application for the presentation medium (program, trainee, or both).
- Stimulus Content. Visual, verbal, or audio.
- Next Learning Activity. The mechanism controlling the presentation sequence of items (program, instructor, or trainee).

Response acceptance mechanisms are further characterized in terms of:

- Pacing Controller. Trainee, instructor, or program
- Next Learning Activity. Program, instructor, or trainee
- Type of Evaluation Provided. Individual versus group; selected versus constructed
- Feedback. Immediacy (immediate versus delayed); source (intrinsic versus extrinsic)

Appendix B, Figures B-10 and B-11, contains the method selection tables proposed for use in the TAM. Appendix B provides a detailed example of how stimulus presentation medium and the response acceptance mechanism characteristics are used to identify a preferred method of instruction. The methods of instruction proposed for the TAM are listed below.

- Case Study
- Computer-Aided Instruction
- Demonstration
- Games
- Group Interview
- Guided Discussion
- In-Basket Exercise
- Peer Tutor
- Programmed Instruction
- Programmed Practical Exercise
- Role Playing
- Study Assignment Book
- Traditional Classroom
- Traditional Practical Exercise
- Tutoring

Modifications to the list above which will be made during the development phase include the addition of CIVD as a method of instruction.

As a check on the validity of the instructional method selection process, the user also compares recommended instructional methods with the learning algorithm to insure that the two are compatible. Compatibility is determined by the source and immediacy of feedback that can be provided within the context of a particular learning algorithm. Figure B-12 presents the Learning Algorithm-Instructional Method compatibility table used in the TAM.

Training Setting. The final aspect of the training prescription element involves specifying a training setting. Training settings commonly available within a military

environment are selected on the basis of three criteria, listed as follows:

1. The number of trainees likely to be involved (a small number versus five or more).
2. The nature of trainee interactions (individual versus team).
3. Whether or not equipment manipulations are required.

Training settings currently employed in the TAM are listed as follows:

- Small Group Site
- Large Group Site
- Individual Carrel
- Small Group Carrel
- Traditional Classroom

Figure B-13 presents the logic of the training setting selection process.

In summary, the TAM's training prescription decision process results in a series of training recommendations for each task under consideration. The training prescription includes the following information:

- Learning Algorithm. A model instructional approach
- Stimulus Presentation Medium. The medium used in presenting the stimulus content of a task
- Response Acceptance Mechanism. The medium used in accepting and evaluating trainee responses and in providing feedback (i.e., knowledge of results)
- Instructional Method
- Instructional Setting

Figure 9 provides an overview of the complete training prescription generation process.

Training Priority, Time, and Option

Element three of the TAM is concerned with training priority, training time, and training option. Training priority involves the level of training to be provided for a given task.

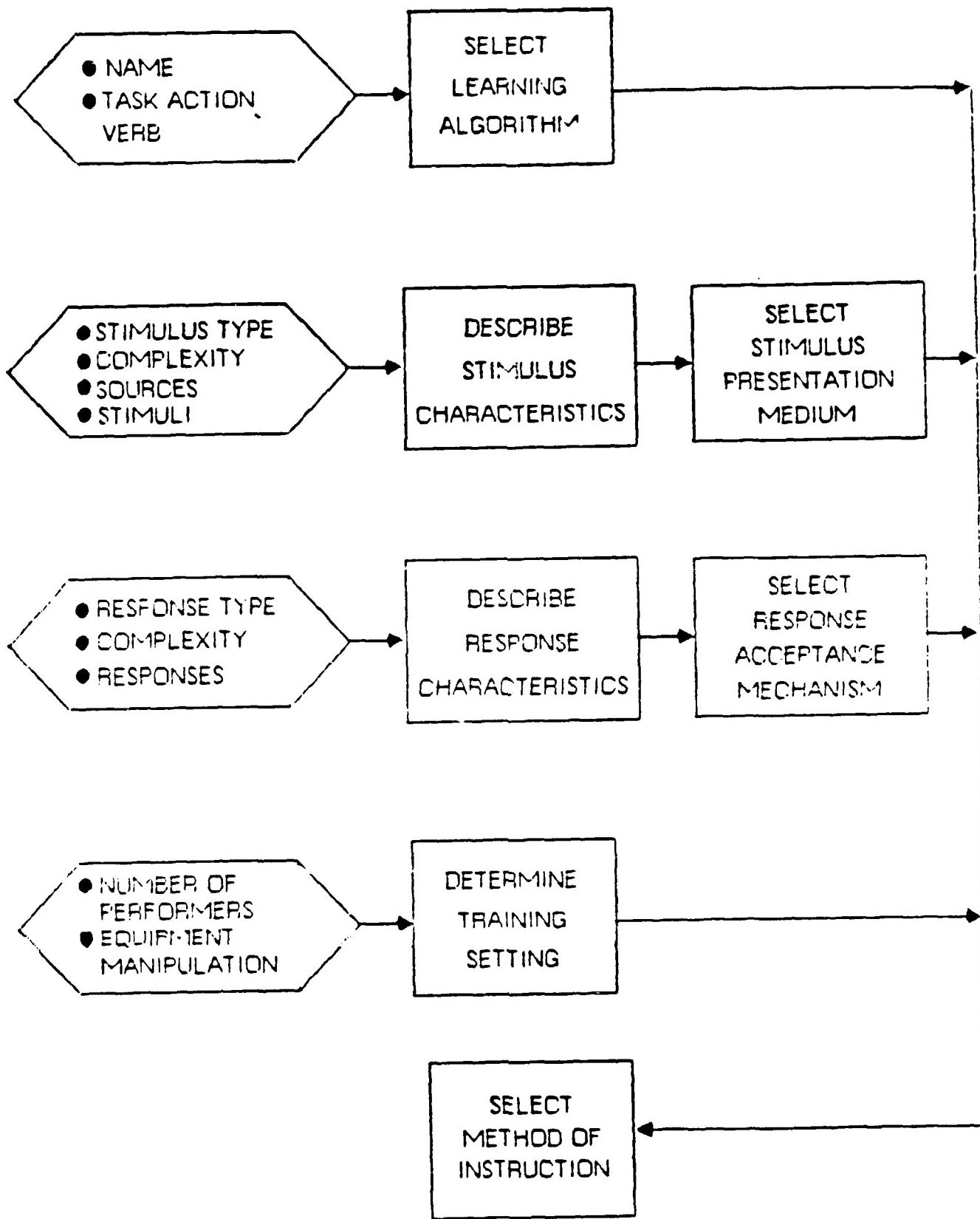


Figure 9. Training prescription generation

Time does not permit training all tasks in a resident instructional setting. Training priority ratings, when combined with training time constraints, are used to determine which tasks should be trained in a resident setting, those that can be relegated to OJT, and those that require no formal training (i.e., informal OJT is likely to be sufficient).

Training priority is determined on the basis of user responses to the ten critical dimensions shown in Table 6. Based on these responses, tasks are sorted into one of three training level categories:

1. Certification. Proficiency for each and every task procedural step must be demonstrated. These are usually highly critical tasks such as those performed in emergency situations.
2. Qualification. The trainee must demonstrate proficiency on a sample of the procedural steps in a task.
3. Familiarization. A demonstration of task-related activities is sufficient.

Criticality ratings are also used for other training-related purposes. For example, tasks that can be trained in less time during mobilization are identified. Tasks that are performed only in wartime are identified for special mobilization training. And finally, tasks which are based upon skills that deteriorate quickly when not in use are identified as requiring periodic refresher training.

The second aspect of element three concerns training time. In this regard, training specialists are asked to provide estimates of the length of time required to reach the performance criterion for each task, given the instructional medium and method used and the Target Audience Description. In making training time estimates, users should consider predecessor or referent system training times, as well as the results of any relevant training effectiveness analyses (i.e., a post-fielding TEA on a predecessor or referent system). Both the target audience and predecessor training system information required to complete this analysis are contained in data bases produced by the training constraints module (TCM).

The selection of a Training Option--Resident Instruction, OJT, or No Formal Training--is relatively straightforward. Tasks that require a Certification level of training are selected for Resident instruction; tasks that require Qualification-level training are selected for either Resident instruction or formal OJT; and tasks requiring only Familiarization training are relegated to OJT or slated to receive no formal training. Training time constraints that are evident following the completion of the Training Program Synthesis step (Element 4) are used to further separate tasks into Training Option categories.

Table 6

Task criticality dimensions

Task Criticality Dimensions

- A. Learning Difficulty - Is the task hard to learn?
L - Easy to learn - can be self-trained
M - Some difficulty in learning - requires some assistance to learn
H - Hard to learn - requires supervision, extensive practice or special equipment or environment
- B. Performance Difficulty - Is the task hard to perform?
L - Easy to perform - can perform correctly on initial effort and each repetition - include only simple skills
M - Some difficulty in performing - requires practice and some supervision to perform - moderate level skills
H - Hard to perform - additional practice and supervision required for performance - high probability of some performance failures - includes complex skills or skills integration
- C. Time Delay Tolerance - What is the time allowed between receiving the task cue and starting the performance?
L - No need to start task at any specific time
M - Task start can be delayed for several minutes
H - Must begin immediately or within a few minutes after cue
- D. Consequence of Inadequate Performance - How serious is the effect of improper performance or non-performance on unit or individual missions?
L - Has little or no effect on mission of individual or unit
M - Could degrade or delay mission performance
H - Could result in mission failure
- E. Immediacy of performance - How soon after arrival in field unit could task performance be required in wartime?
L - Not for several months
M - Within the first several weeks (4-12 weeks)
H - Within the first one to four weeks
- F. Civilian Acquired Skill - What is the probability the task requires new skills not generally available in the target population
L - All skills are civilian acquired by the time of initial entry
M - Some of the skills are civilian acquired by the time of initial entry
H - Few or none of the skills are civilian acquired by the time of initial entry

Table 6

Task criticality dimensions (continued)

- G. Task Importance - Is the task important to the survival of personnel and equipment?
- L - Failure or non-performance would have little or no effect on survival of personnel or equipment
 - M - Failure or non-performance could endanger personnel or equipment
 - H - Task must be performed for survival of personnel or equipment
- H. Frequency of Performance - How often is the task called for in peacetime operations and training?
- L - Infrequently - less than once per month
 - M - Occasionally - one or two time per month
 - H - Frequently - at least once per week
- I. Wartime Task - Is the task oriented towards wartime operations?
- 1 - Peacetime only - task is not performed during wartime
 - 2 - War & Peace - task can be performed both in peace and in war
 - 3 - Wartime only - task is never performed or practiced until wartime
- J. Proficiency Decay Rate - How frequently must the task be performed to assure that skills are not reduced below standards?
- L - Task skills require little or no practice to retain proficiency
 - M - Task requires infrequent practice - once every one to three months
 - H - Frequent practice required - more often than once a month

In summary, the results by task provided through the exercise of element four are:

- Training Level Recommendation. Certification, qualification, or familiarization
- A Training Time Estimate. The training time judged necessary to meet the performance criterion
- Training Option Recommendations: Resident, OJT, or No Formal Training

Figure 10 provides a summary overview of the steps comprising element three of the Analysis module.

Training Program Synthesis

The fourth element comprising the TAM concerns training program synthesis. During this portion, users integrate the results from the previous elements to produce a tabular description of total-system training requirements. This tabular description can serve as the basis for the development of an Outline Individual and Collective Training Plan.

The basis for the tabular description of training requirements is the Training Task Matrix, a portion of which is shown as Figure 11. Dimensions defining the Training Task Matrix are:

- Task Category:
 - Operations
 - Maintenance
 - Support
- Type of Training:
 - Initial Skill Acquisition
 - Individual and Team Tactical Performance (Unit)
 - Combined Arms (Multi-Unit)
 - Skill Maintenance (Refresher)
- Rank of Typical Task Performer
 - E2 - E4 (first-term enlisted)
 - E5 or above (career enlisted)
 - Officer

Tasks are arrayed along dimension one by category (operations, maintenance, or support); within categories, tasks can also be broken out by tentative job positions (i.e., MOSS) if such information is available. Entries in the matrix then consist, by task, of: (1) the training prescription, (2) training level, (3) training time, and (4) the training option (i.e., Resident, OJT, or No Formal Training). When the time available for training by training type and by tentative job

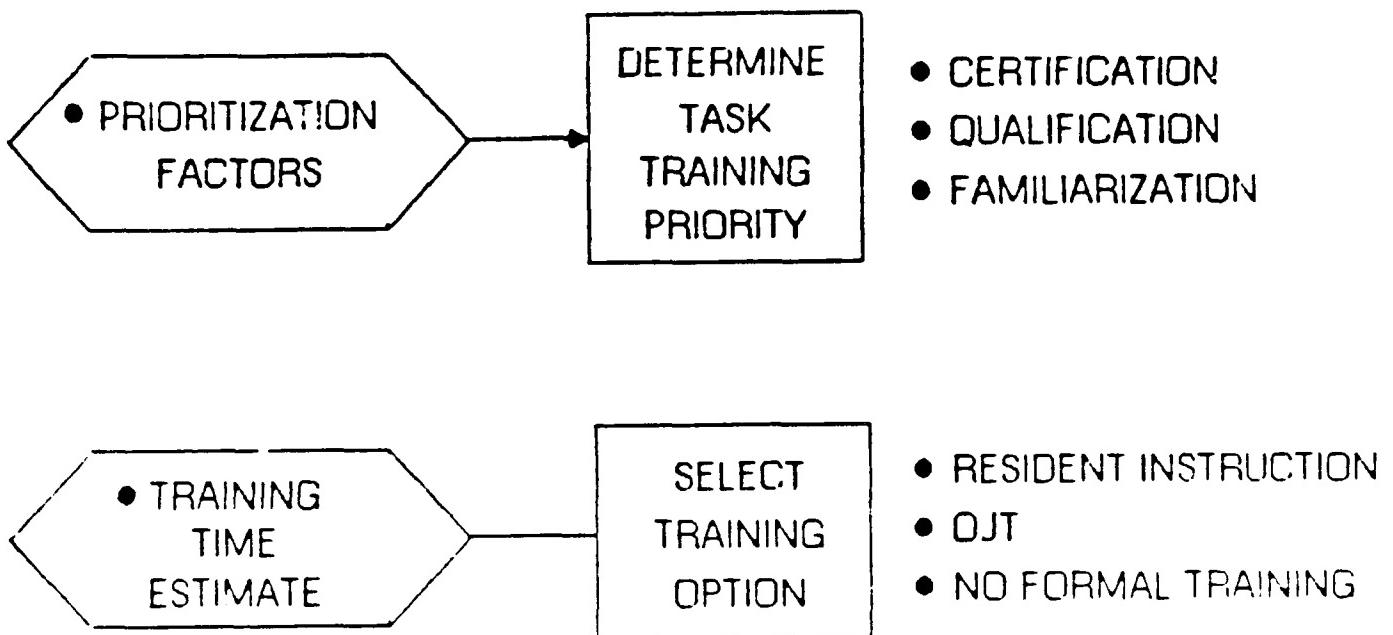


Figure 10. Training priority, time, and option.

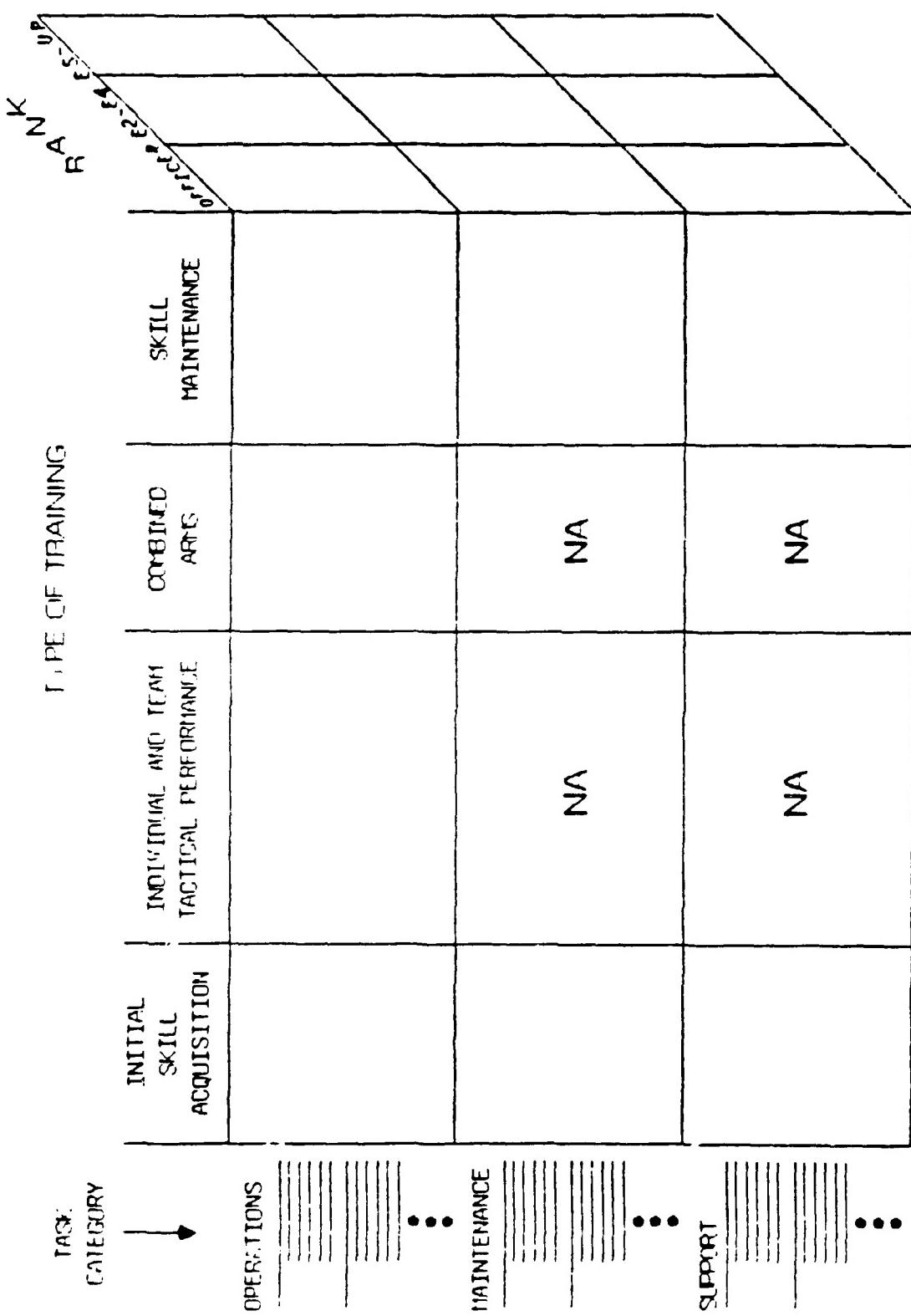


Figure 11. Training task matrix.

position (derived from the Constraints module) is compared with aggregate training times, a more complete characterization of training options can be made. Recall that upon completing the previous element, some tasks might be recommended for either Resident Instruction or OJT. The total time available for resident training will aid in resolving such ambiguities regarding training location.

The information provided in the Training Task Matrix can serve as the basis for the development of a total-system training concept. In addition, the information necessary to support initial training device concept development (i.e., an initial TDS) is present. Users thus have much of the information required to develop an OICTP. These latter issues are, however, beyond the requirements of the current effort.

At this point in the TAM, the user will have constructed a general description of an "optimal" or recommended training program for the materiel system of interest. To accomplish the goals of the current SOW, this "optimal" training system must now be modified based upon the information developed by Training Constraints Model (TCM). This modified training description will represent the "most likely" training to exist for the system. The next section describes the process which will be used to derive the "most likely" training program.

Training Resource and Constraint Assessment

The transformation of the description of an "optimal" training program provided by the fourth element to the "most likely" training program produced by the fifth element of the TAM is a five step process. The principal steps in the process include:

1. Modification of the Training Task Matrix by eliminating methods of instruction or not listed as feasible in output from the training technology constraints data base of the TCM.
2. Adjustment of any segment of the recommended training program which requires more resources in any resource category than the level identified as available in the training resources constraint data base.
3. Development of a dynamic resource consumption matrix based on a training outline formed from the predecessor training system resource requirements matrix and the training prescription produced by the TAM.
4. Development of a most likely training outline with a dynamic resource consumption matrix that fits within the training resource constraints boundaries identified in the TCM resource constraints data base.

5. Modification of the Training Task Matrix existing after step 2 (above) to fit within the time and resource boundaries of the training outline developed in step 4.

Each of the five steps is described in detail below.

Elimination of Training Methods and Technology. The easiest and most straightforward modification to be made to the recommended Task Training Matrix will be the elimination of methods of instruction which the TCM identified as unlikely to be available. After eliminating those methods of instruction which the TCM identified as unavailable, the user will repeat the instructional method selection process for the affected tasks by selecting available methods with the greatest number of matches to requirements imposed by the stimulus presentation medium and response acceptance mechanism requirements. A new Task Training Matrix will be produced at the end of this step.

Adjustment for Exceeding Resource Availability. The first adjustment for exceeding training resource availability will occur in the second step of the modification of the recommended training program. This will be a relatively straightforward comparison of the total requirements for classrooms, instructors, etc. indicated by the Task Training Matrix with the availability limits in the training resource constraints data base. The adjustments which might be made may include reducing the amount of time devoted to resident training, increasing the student/instructor ratio, shifting some training tasks to on-the-job training, etc.

Violations of available training resource constraints are fairly easy to identify for resources found in resident training environments. Furthermore, since resident instruction is individually oriented, adjustments to instructional programs can be made with the assumption that scheduling of individuals to attend courses can be modified to some degree.

Identification of training resource constraint violations for unit training are considerably more complex and more difficult to correct. This problem is particularly acute during the time that a new system is being fielded. It is at this time that the training system and the units being trained are all in a state of transition. The distribution plan for the new system, unit training resource consumption rates, and conflicting scheduling for limited resources such as gunnery ranges must be considered simultaneously in projecting the most likely training which will actually occur in units receiving the new materiel system. The development of a dynamic resource consumption matrix is the first step in solving this problem.

Development of the Dynamic Resource Consumption Matrix. One of the data bases developed in the TCM is a predecessor system training resource requirements matrix. As described earlier, this data base provides a matrix of resources consumed during

each phase of training for a single training cycle with the predecessor system. This matrix provides the starting point for the development of a dynamic resource consumption matrix for the materiel system of interest. The development of the dynamic resource consumption matrix involves the four steps listed below:

- Modify the predecessor training system outline to match the training outline of the new system
- Determine the resource consumption rate for a single cycle of the new training outline
- Model the total resource consumption for all units receiving the new materiel system
- Output the dynamic resource consumption matrix

The modification of the outline of the predecessor training system to match as closely as possible the anticipated training outline of the new system concept is based on known or expected differences between the systems. Of most importance are changes that directly affect the need for training resources. This process will be somewhat subjective and will require subject matter expertise and familiarity with the predecessor materiel system and the new system concept. The important factor is to carefully document all decisions and record the logic used to modify resource demands. Figure 12 illustrates a simple collective training outline for an aviation system.

Once a new system training outline has been determined and the accompanying training resource consumption rate for a single cycle of training specified, the next step is to model total resource consumption over time for all units receiving the new materiel system. The actual mathematical model used to calculate resource consumption is a four dimensional model. A discussion of the structure and function of the model is beyond the scope of the current effort. The essential point to be made is that the model makes it possible to examine the training schedule and resource consumption (by type of training resources) for all units training with the new system. The model provides information regarding aggregate resource consumption for each fiscal year and allows one to identify total resource demand (by critical training resource category) at any point in time. This model produces the output referred to as the dynamic resource consumption matrix. This matrix is most easily examined in a graphic form. Figure 13 presents a sample printout of the resource consumption for one class of training resources over a single year.

Development of a Most Likely Training Outline. The dynamic resource consumption matrix output will identify violations of resource constraints developed in the TCM. More importantly, the model also allows one to adjust the training outline for unit training to test alternative training programs which result in

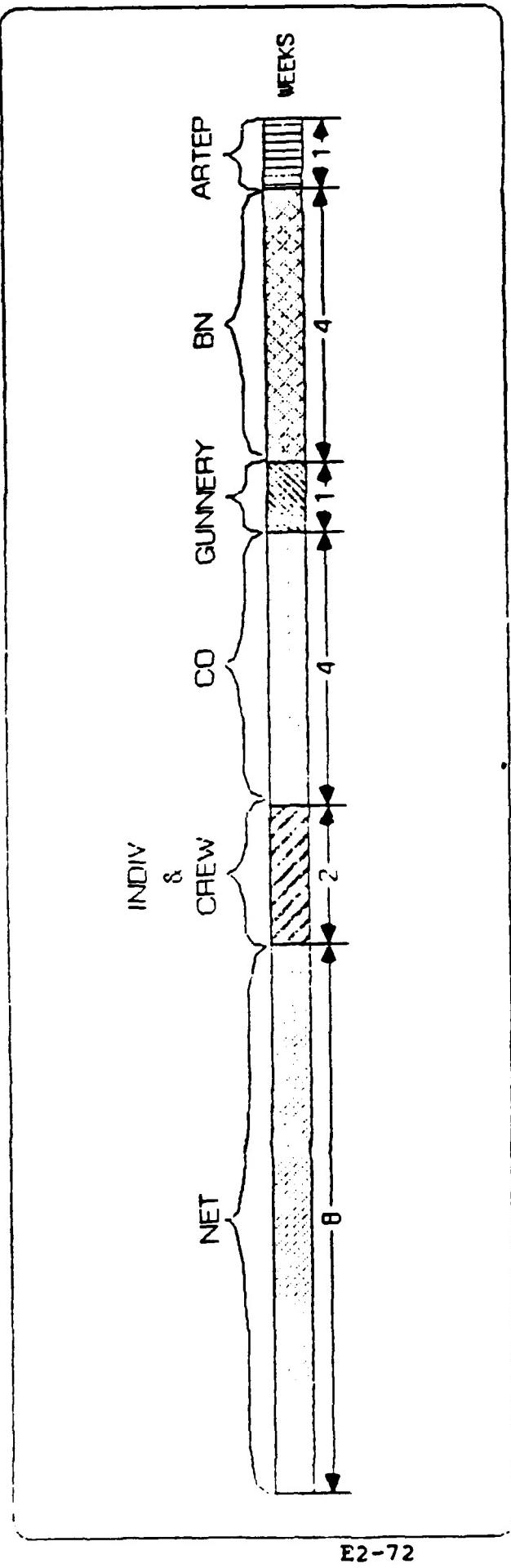


Figure 12. Timeline of training outline.

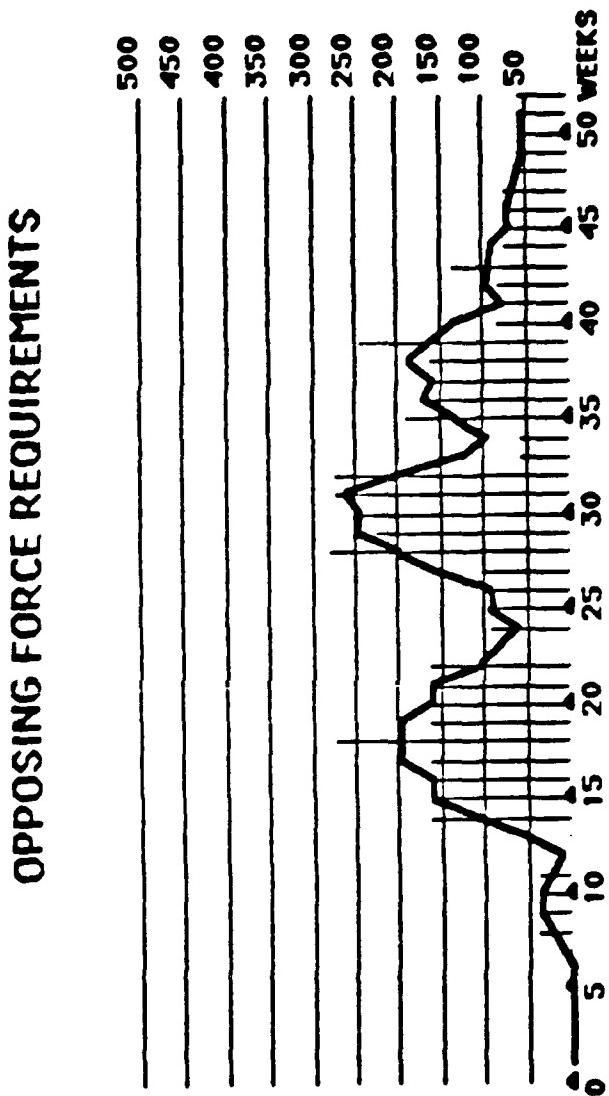


Figure 13. Dynamic resource consumption matrix.

resource consumptions below projected limits. Examples of adjustments to the training outlines include extending or shortening times for particular segments of training, using simulators instead of live fire ranges, etc. The efficient generation of such alternatives requires familiarity with the materiel system concept and unit training processes. However, the model provides very rapid feedback on the impact of such changes on resource consumption.

The model calculates other measures in addition to resource consumption. These measures of the relative effectiveness of the training outline alternatives include the average length of time required to complete a training cycle and the average "down" time for each unit.

Through an iterative process of testing alternatives, the user will develop a training outline of the collective training which consumes resources at a rate within the limits established by the TCM. This training outline with its associated resource consumption rate is considered the "most likely" structure for the collective training for the system.

Modification of the Task Training Matrix. The "most likely" training outline produced through the modeling of dynamic resource consumption described in the previous step must now be compared to the collective training tasks in the Task Training Matrix. Modifications in the training time, methods, location, and other factors must be made to the matrix to "fit" the training outline developed in the previous step. This modified Task Training Matrix will now represent the TEM's estimate of "most likely training."

TAM Output

The output from the analysis module includes all of the items required under TRADOC Regulation 350-4. This includes a consideration of the following:

- What is to be trained: (Task Statement) -
 - Action Verb
 - System Equipment
 - Support Equipment
 - Standards
 - Conditions
- How training will be done: (Learning Prescription) -
 - Learning Algorithm
 - Stimulus Medium
 - Response Acceptance Mechanism
 - Method of Instruction
 - Learning Setting

- Where training will be done: (Training Option(s)) -
 - Resident Instruction
 - OJT
 - No Formal Training
- When training will be done
 - Decisions pertinent to when training should be conducted can be made on the basis of information contained in the Training Task Matrix--rank of task performer crossed with type of training in question.

Used in combination with the Constraints module, the TAM also provides users with a quick determination of the type of training, by task, likely to be provided for an emerging system. Thus, the TEM will identify both an "optimal" Task Training Matrix and a "most likely" Task Training Matrix. Those areas in which there are major discrepancies between the two training descriptions are areas which should be of major concern to the material system designers as well as the training system designers. Thus, the exercise of the two modules will provide Army training developers with much of the information necessary to define an appropriate training concept, identify potential constraints, estimate the impact of the constraints on the nature of the projected training system, and identify potential training performance deficiencies resulting from the training constraints.

The Feedback and Interface Module (FIM)

The final module of the TEM is the Feedback and Interface Module (FIM). The FIM serves as the output generator and storage facility of the TEM. The FIM provides the TEM with report generation capabilities to communicate the results of exercising the TCM and TAM. The FIM will also provide the user with a standard query capability for any of the data bases developed within the TCM or TAM.

The exact nature of the reports generated by the FIM will be determined through research conducted with the potential TEM users. The report formats and content will be tailored to meet the users' needs to provide training-related information for the PTEA and CTEAs and other system acquisition related documents. This will include providing information to support the training concept, training device concept, inputs to the ROC, and inputs the materiel system RFP.

In addition to meeting the needs of the training developers, the FIM will provide valuable data to the materiel system designers. As noted earlier, in addition to the information describing the "most likely" training for each task identified by

Product 1, the FIM will generate reports related to potential training problem areas and predecessor system training problems which may have been related to interface design problems.

The FIM will be developed from standard, commercially available software.

Development of the TEM

The authors have already noted that the major factors which we feel must be considered in the design and development of the TEM are the needs of the user and the user's environment. The plan for the development of the TEM reflects this factor as the primary "high driver." As currently structured, the current effort has two remaining phases, a product design and a product development phase.

The key to successful development of Product 4 will be in designing the product to ensure user acceptance and institutionalization of the methodology. For this reason the next action we recommend in design of Product 4 is an in-depth analysis of user needs and the likely hardware and software systems which will exist when Product 4 is ready for distribution to users. As noted earlier, we believe that the members of the DOTD-NSTO will be the primary users. The next step in development of Product 4 will be to establish the information requirements, characteristics, and user biases which exist for this target audience. This information is particularly critical for the development of the Feedback and Interface Module (FIM). It is through the user needs analysis that we will establish the most appropriate content and format to be included in reports generate by the TEM.

There should be user involvement in the remainder of the design and development process to aid in acceptance and institutionalization of the product. Members of the user community should be briefed on the concept for Product 4 and provided with the opportunity to make recommendations for modifications of the type of information output they require and the best way to provide training on the product. Establishing the degree of computer literacy in the user population will be a critical factor in aiding the development of a product that gains user acceptance.

An additional aspect of the user needs analysis will be to identify means through which the TEM might be institutionalized within the user community. This includes identification of formal training settings (schools and courses) in which the users previously obtained information related to training analysis.

Additional data related to this topic will include an assessment of the viability of CBT embedded in the TEM as a means for training the users.

A second type of information required for development of Product 4 is identification of the hardware and software systems currently used in DOTD offices at various combat development centers. We currently plan to provide the finished TEM for an IBM compatible system.

In developing the prototype for Product 4, HTI will ensure that the tool's architecture is comfortable to TRADOC's emerging Schoolhouse concept, denoted the Training Support System (TSS). The TEM may be incorporated into the TSS or it may function best as a stand-alone methodology for use with more powerful micro-computers.

Initial prototypes for major portions of the TEM are already in existence. The majority of the TAM has been programmed on a mainframe computer and tested in several experimental studies. The structure of the model used to calculate the dynamic resource consumption matrix has also been completed. The prototype of the resource consumption model has been used successfully in training analyses conducted during the concept development phase of a major system. The model currently resides on a micro-computer.

Thus, the major model prototyping which must be completed for development of the TEM lies in the development of prototypes of the major elements of the TCM. Since the TCM is essentially a data base development module, the programming required to implement these portions of the model is fairly routine. In fact, as part of the prototyping conducted for Product 2, HTI has successfully programmed routines which allow the user to dimensionalize spreadsheets using a menu driven system requiring no working knowledge of spreadsheet development. The user must only respond to prompts by indicating the number of categories and corresponding labels for each dimension of the model. The programming required for all of the TCM components can probably be accomplished using standard data base programming packages such as dBase III+.

The most significant developmental task for the TEM besides ensuring user acceptance is the development of the user guidance for obtaining constraints data included in the data base programs of the TCM. This will require continued research and interactions with users to identify the most helpful documents from which to derive training resource constraints data. We must also identify the best sources for obtaining such documents or information. As noted earlier, now that we have identified the major sources of the information, the developmental task at hand is to provide more specific guidance as to where and how information can be obtained in an efficient manner. This will require analysis of various types of training documentation produced and maintained by agencies such as the proponent combat

development centers, PM-TRADE, selected elements of the DA Staff, and selected elements of TRADOC, FORSCOM, and other MACOM headquarters. If at all possible, the TCM data base programs will be designed to allow electronic transfer of training resource data from existing computer data bases such as the AETIS and AIMS.

Institutionalization of Product 4

While considerable time has already been devoted to discussion of the design and development steps taken to aid in gaining acceptance and institutionalization of the TEM, it is important to note the steps required in implementation of the TEM. The authors believe that institutionalization of Product 4 will occur only if TRADOC identifies an internal proponent for the product. The product must become an accepted part of the training analysis portion of system acquisition process. The use of the TEM must be part of the formal education and training system for training developers and TRADOC must support the product with necessary documentation and software modifications to improve the product as new information becomes available and the user community gains experience with the product.

If TRADOC assumes this proponent role and the TEM has been successfully designed to meet the needs of the user audience, the product will be institutionalized. If either ingredient is missing, however, Product 4 will join the ranks of other discarded models and methods to automate or formalize the training analysis process. While HTI has attempted to ensure that the TEM meets the needs of the DOTD users, the responsibility for acquiring the TRADOC blessing and proponency of Product 4 or any of the other MPT Estimation Products will rest primarily with the Army Research Institute.

User Training

The TEM is designed to be as user friendly and self-guiding as possible. As was described earlier, the automated portions of the methodology are menu driven and prompt the user for required input. The online user prompts and help functions will be supported by documentation which clearly outlines all functions (both automated and manual) required of the user.

Ideally, the users would receive some formal training in a classroom environment to at least familiarize them with the concepts and procedures involved in using the TEM. This is viewed as unlikely, however, and the user prompts, on line help, software documentation and overview training manual accompanying the TEM will be pilot tested with a sample of users to ensure that they provide adequate training for the product.

Person Hours Required to Use the Product

One of the goals for Product 4 was to develop a relatively quick method for estimating the most probable training. As we developed the TEM and worked another early-on training analysis for a major Army system it became apparent that the problem of developing a useful estimate of most likely training is a complex task. On the other hand, we have also learned that it is not the entry or analysis of the data which is time consuming, but rather, it is the collection of the data. This is why the development of the TEM will include a major focus on development of on-line guidance to help users identify data sources and to guide extraction of data from existing documentation. This aspect of TEM should provide a major time savings for users of the product.

The estimate for total person-hours required to exercise the TEM for analysis of a comprehensive training program on a major acquisition is approximately 560 person-hours. This estimate is based on our experience with the pilot testing of the TDDA which is the predecessor to TAM and research we have conducted using the dynamic training resource consumption model which requires the collection of much of the data used in the TCM of the TEM. The estimate may increase or decrease by approximately 25% depending on the degree to which the user possess the documents and data required to derive training constraints information. If the user has a reasonable collection of predecessor training system documentation and a current inventory of relevant training resources from the proponent schools and units receiving the new units, the person hours are likely to be reduced by 25%. If the user is starting from scratch on collection of data sources, the person hours expended will probably increase by 25% or more.

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APPENDIX A
TASK VERB-LEARNING ALGORITHM LISTING

| <u>VERB</u> | <u>ALGORITHM</u> |
|----------------|---|
| Abide by | Attitudes |
| Accepting | Attitudes |
| Accommodate | Problem Solving |
| Acquire | Steering & Guiding Continuous Movement |
| Activate | Motor Chaining |
| Adapt | Problem Solving |
| Adjust | Motor Chaining |
| Adjust to | Problem Solving |
| Advise | Communicating |
| Aim | Steering & Guiding Continuous Movement |
| Align | Motor Chaining |
| Allocate | Classifying |
| Analyze | Rule Using |
| Answer | Communicating |
| Anticipate | Rule Using |
| Apply | Rule Using |
| Arrange | Classifying |
| Assemble (Dis) | Motor Chaining |
| Assign | Classifying |

VERBALGORITHM

| | |
|--------------|---------------------|
| Associate | Identifying Symbols |
| Attend | Monitoring |
| Calculate | Classifying |
| Catalogue | Classifying |
| Categorize | Classifying |
| Characterize | Classifying |
| Check | Rule Using |
| Choose | Decision Making |
| Cite | Verbal Chaining |
| Classify | Classifying |
| Clean | Motor Chaining |
| Close-Open | Motor Chaining |
| Collect | Classifying |
| Compare | Identifying Symbols |
| Compensate | Steering & Guiding |
| | Continuous Movement |
| Compile | Classifying |
| Comply with | Attitudes |
| Compose | Problem Solving |
| Compute | Rule Using |
| Conclude | Rule Using |
| Conform to | Attitudes |

VERBALGORITHM

| | |
|---------------|---|
| Connect (Dis) | Motor Chaining |
| Construct | Problem Solving |
| Contrast | Identifying Symbols |
| Contrive | Problem Solving |
| Control | Steering & Guiding Continuous Movement |
| Converse | Communicating |
| Convert | Rule Using |
| Coordinate | Rule Using |
| Copy | Motor Chaining |
| Correlate | Decision Making |
| Create | Problem Solving |
| Cut | Gross Motor Skills |
| Deduce | Rule Using |
| Demonstrate | Rule Using |
| Design | Problem Solving |
| Detect | Monitoring |
| Determine | Decision Making |
| Develop | Problem Solving |
| Devise | Problem Solving |
| Diagnose | Decision Making |
| Diagram | Rule Using |
| Differentiate | Identifying Symbols |
| Direct | Communicating |

VERBALGORITHM

| | |
|---------------|---|
| Discern | Identifying Symbols |
| Discover | Problem Solving |
| Distinguish | Identifying Symbols |
| Divide | Classifying |
| Draft | Gross Motor Skills |
| Draw | Gross Motor Skills |
| Drive | Steering & Guiding Continuous Movement |
| Energize (De) | Motor Chaining |
| Enumerate | Verbal Chaining |
| Equate | Rule Using |
| Estimate | Rule Using |
| Evaluate | Rule Using |
| Examine | Rule Using |
| Explain | Rule Using |
| Express | Communicating |
| Extrapolate | Rule Using |
| Figure | Rule Using |
| File | Classifying |
| Fly | Steering & Guiding Continuous Movement |
| Generalize | Rule Using |
| Grade | Classifying |
| Grasp | Gross Motor Skills |
| Group | Classifying |

VERBALGORITHM

| | |
|-------------|---------------------|
| Guide | Steering & Guiding |
| | Continuous Movement |
| Identify | Identify Symbols |
| Illustrate | Rule Using |
| Index | Classifying |
| Indicate | Identify Symbols |
| Infer | Rule Using |
| Inform | Communicating |
| Inspect | Motor Chaining |
| Install | Motor Chaining |
| Instruct | Communicating |
| Interpolate | Rule Using |
| Interpret | Rule Using |
| Interview | Communicating |
| Invent | Problem Solving |
| Inventory | Classifying |
| Isolate | Decision Making |
| Itemize | Verbal Chaining |
| Judge | Classifying |
| Label | Identifying Symbols |
| Lead | Steering & Guiding |
| | Continuous Movement |

VERBALGORITHM

| | |
|------------|---|
| Lift | Gross Motor Skills |
| List | Verbal Chaining |
| Listen | Communicating |
| Listen for | Monitoring |
| Load | Motor Chaining |
| Locate | Identifying Symbols |
| Look for | Monitoring |
| Loosen | Gross Motor Skills |
| Lubricate | Motor Chaining |
| Maintain | Motor Chaining |
| Maneuver | Steering & Guiding Continuous Movement |
| Manipulate | Steering & Guiding Continuous Movement |
| March | Gross Motor Skills |
| Mate | Identifying Symbols |
| Match | Identifying Symbols |
| Mix | Gross Motor Skills |
| Monitor | Monitoring |
| Name | Identifying Symbols |
| Navigate | Steering & Guiding Continuous Movement |
| Observe | Monitoring |

VERBALGORITHM

| | |
|-----------|---------------------|
| Operate | Motor Chaining |
| Order | Communicating |
| Organize | Rule Using |
| Pick | Identifying Symbols |
| Pick up | Gross Motor Skills |
| Pilot | Steering & Guiding |
| | Continuous Movement |
| Plan | Rule Using |
| Predict | Rule Using |
| Prepare | Rule Using |
| Prescribe | Rule Using |
| Press | Gross Motor Skills |
| Program | Rule Using |
| Project | Rule Using |
| Pull | Gross Motor Skills |
| Push | Gross Motor Skills |
| Quote | Verbal Chaining |
| Raise | Motor Chaining |
| Rank | Classifying |
| Rate | Classifying |
| Reason | Problem Solving |
| Recall | Verbal Chaining |
| Recognize | Identifying Symbols |
| Regulate | Steering & Guiding |
| | Continuous Movement |

VERBALGORITHM

| | |
|----------------|---------------------|
| Reiterate | Verbal Chaining |
| Relate | Verbal Chaining |
| Remove/Replace | Motor Chaining |
| Repeat | Verbal Chaining |
| Report | Communicating |
| Resist | Rule Using |
| Resolve | Problem Solving |
| Respond | Identifying Symbols |
| Restate | Verbal Chaining |
| Rotate | Gross Motor Skills |
| Run | Gross Motor Skills |
| Schedule | Rule Using |
| Select | Decision Making |
| Service | Motor Chaining |
| Set | Motor Chaining |
| Set up | Motor Chaining |
| Sew | Gross Motor Skills |
| Sharpen | Gross Motor Skills |
| Signal | Gross Motor Skills |
| Sing | Communicating |
| Slide | Gross Motor Skills |
| Solve | Rule Using |
| Sort | Classifying |
| Speak | Communicating |
| Specify | Identifying Symbols |

VERBALGORITHM

| | |
|---------------|---------------------|
| Splice | Gross Motor Skills |
| Steer | Steering & Guiding |
| Stencil | Continuous Movement |
| Study | Gross Motor Skills |
| Stow | Problem Solving |
| Swim | Motor Chaining |
| Synthesize | Gross Motor Skills |
| Testify | Problem Solving |
| Think Through | Communicating |
| Tighten | Problem Solving |
| Trace | Gross Motor Skills |
| Track | Gross Motor Skills |
| | Steering & Guiding |
| | Continuous Movement |
| Transcribe | Rule Using |
| Translate | Rule Using |
| Troubleshoot | Decision Making |
| Tune | Motor Chaining |
| Turn On/Off | Motor Chaining |
| Twist | Gross Motor Skills |
| Verify | Rule Using |
| Wait | Monitoring |
| Watch | Monitoring |
| Weld | Motor Chaining |
| Write | Motor Chaining |

APPENDIX B

TRAINING MEDIA/METHOD SELECTION PROCESS

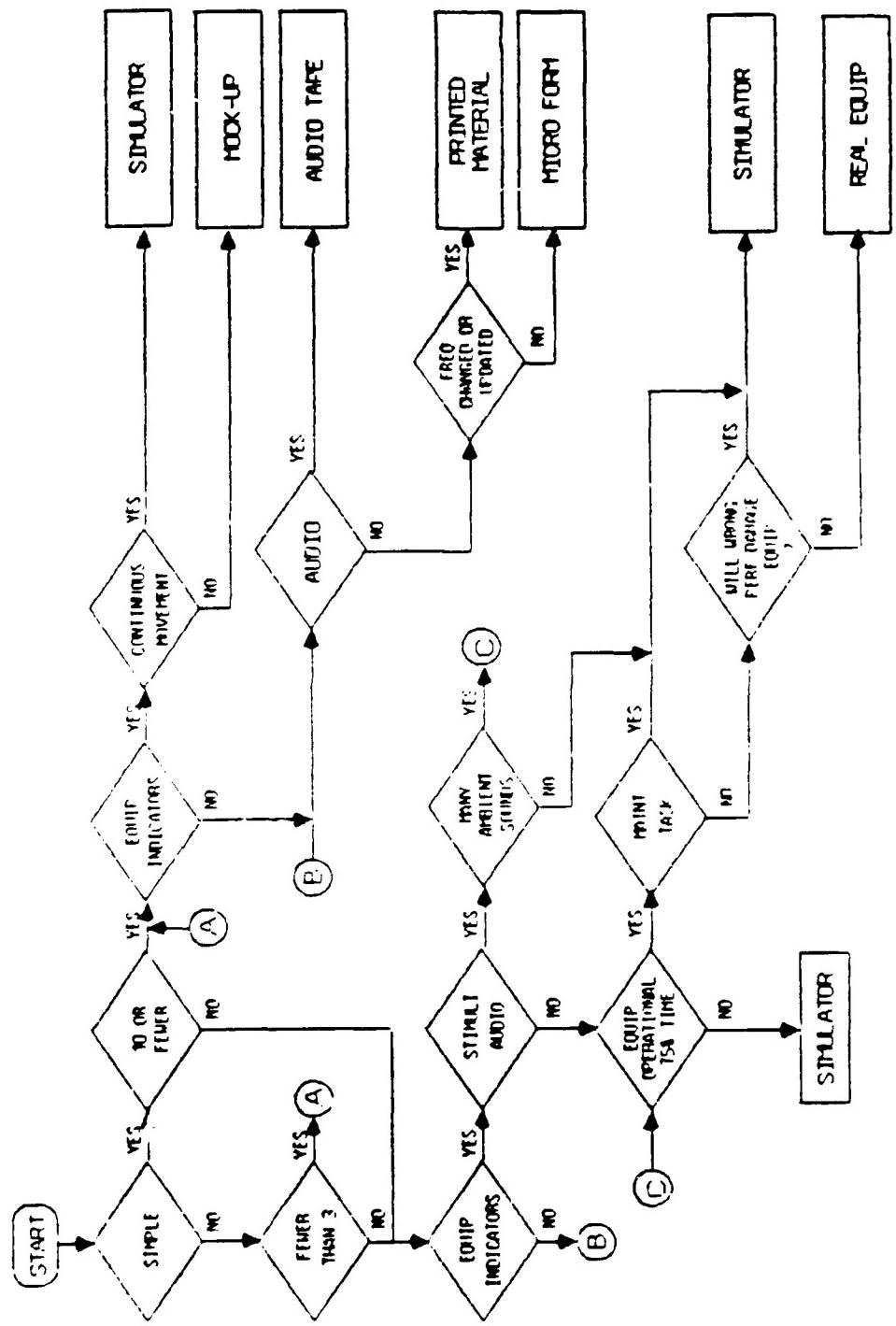


Figure B-1. Verbal stimuli.

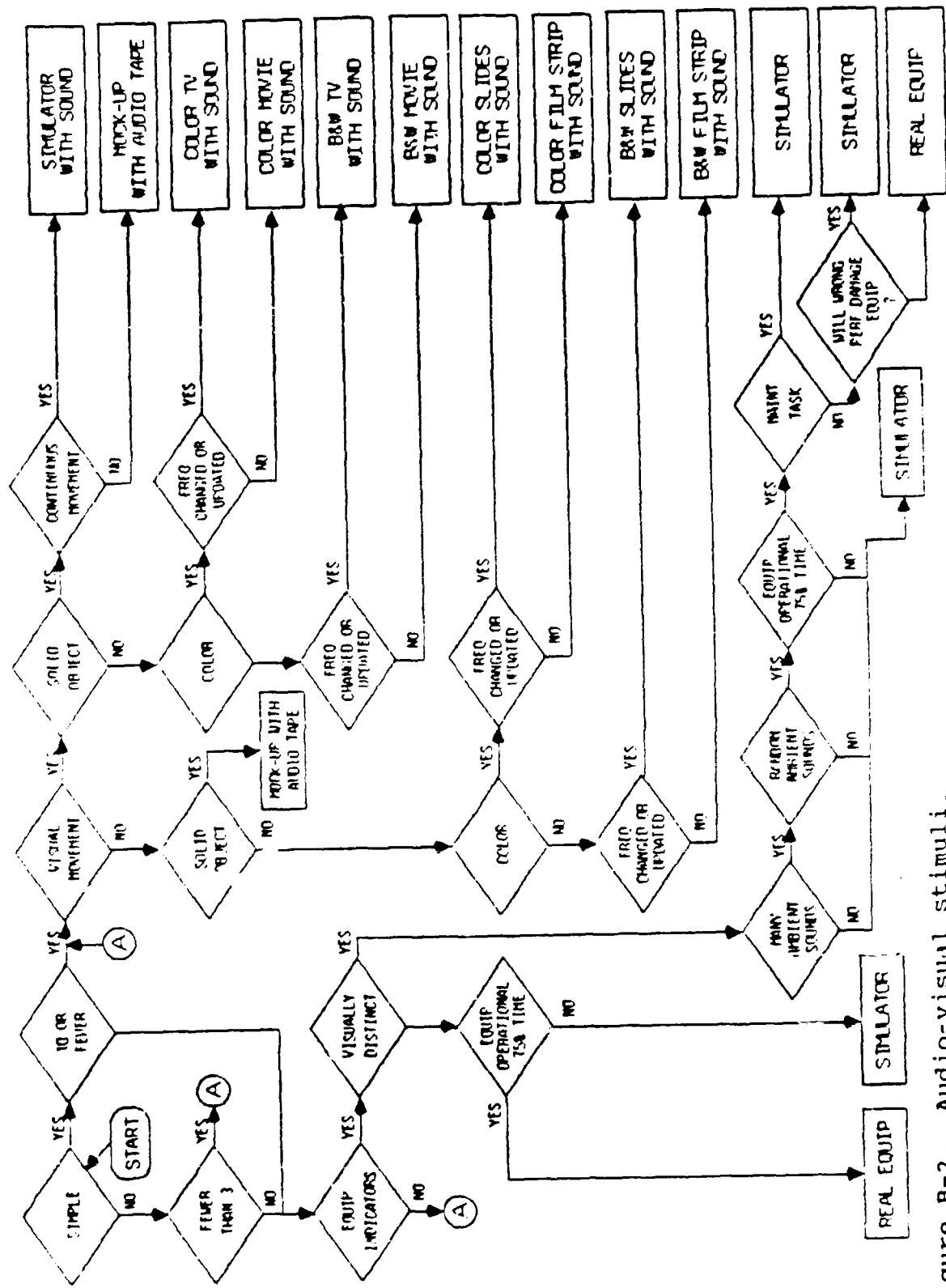


Figure B-2. Audio-visual stimuli

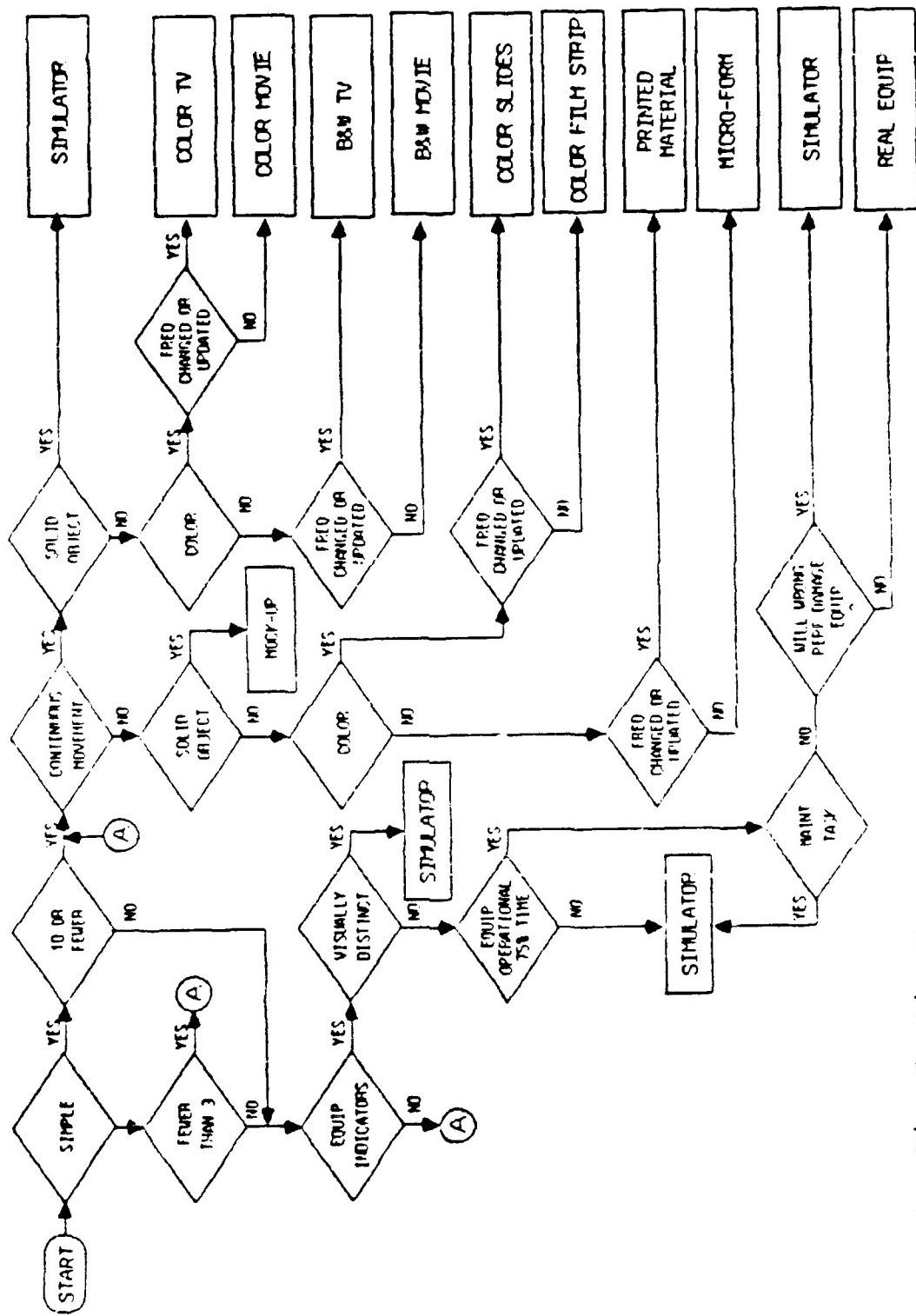


Figure B-3 . Visual stimuli.

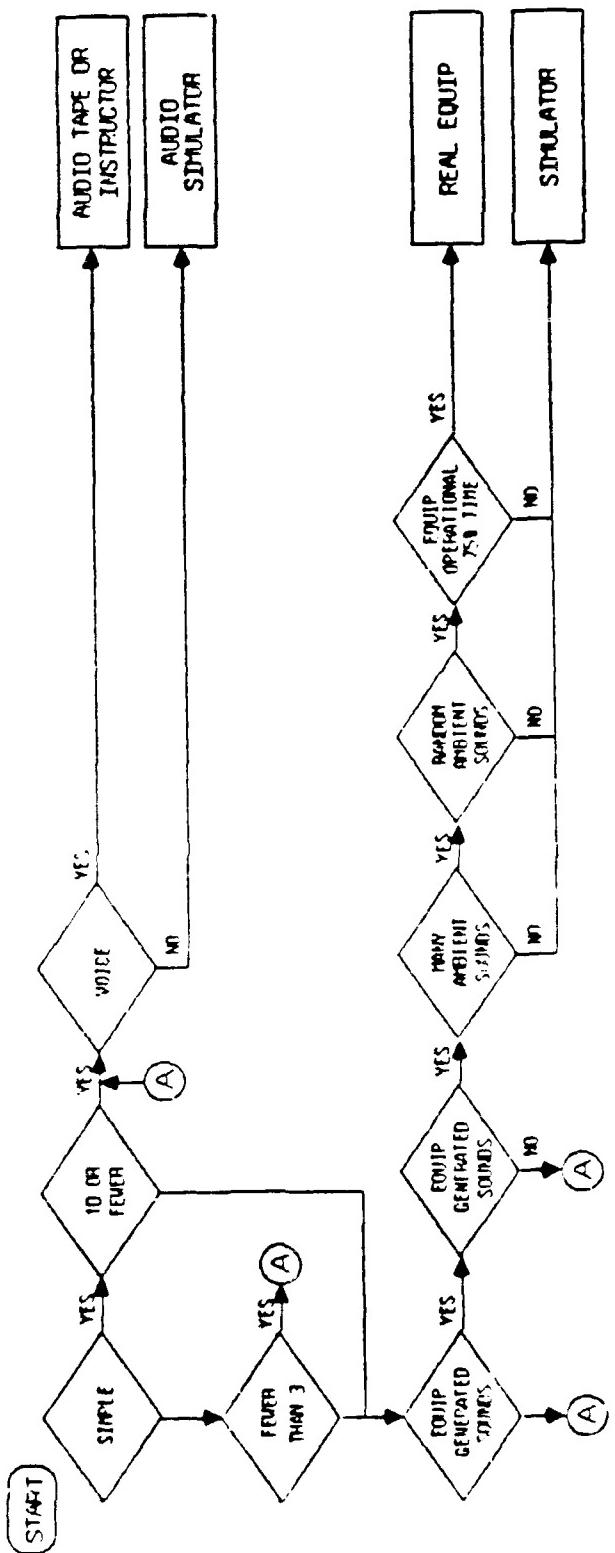


Figure B-4. Audio stimuli.

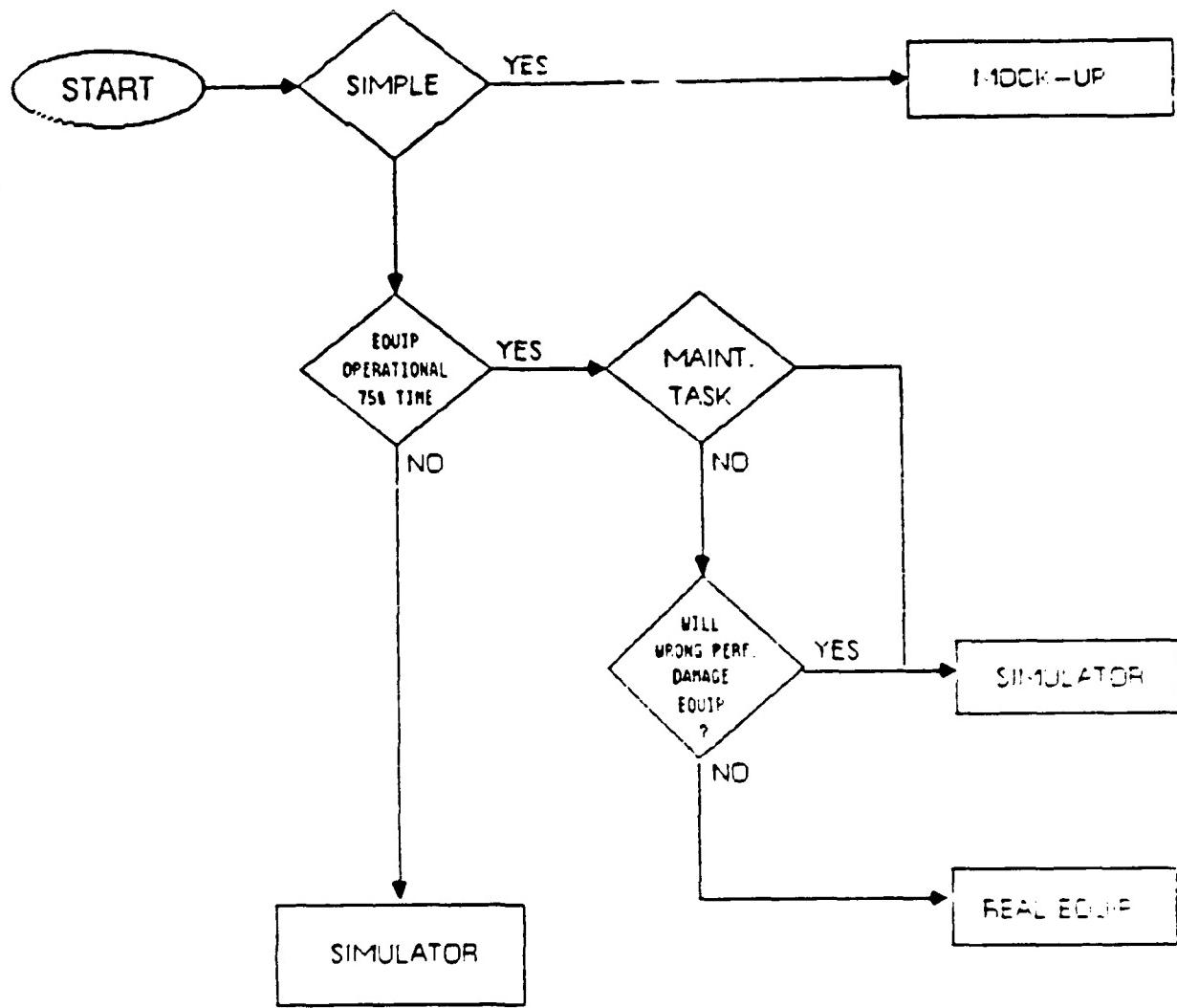


Figure B-5. Tactile stimuli.

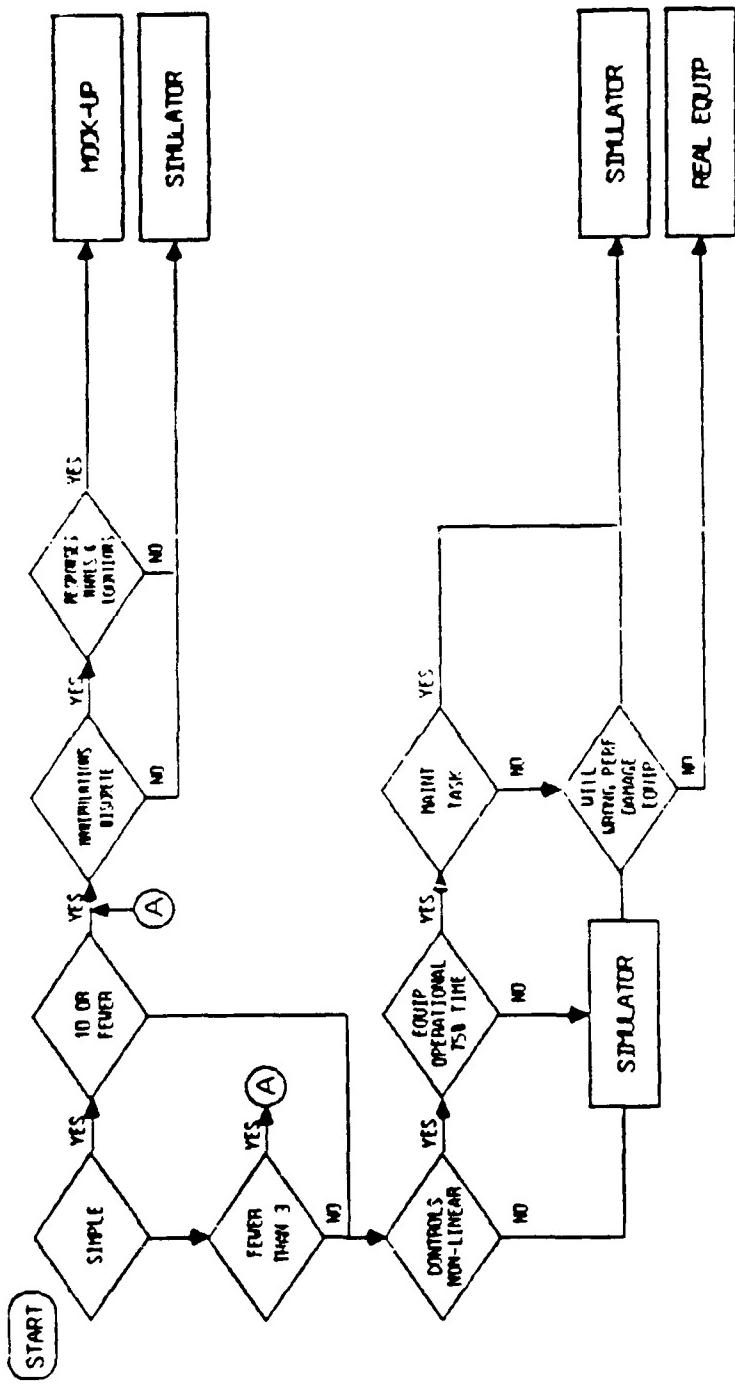


Figure B-6. Equipment manipulation

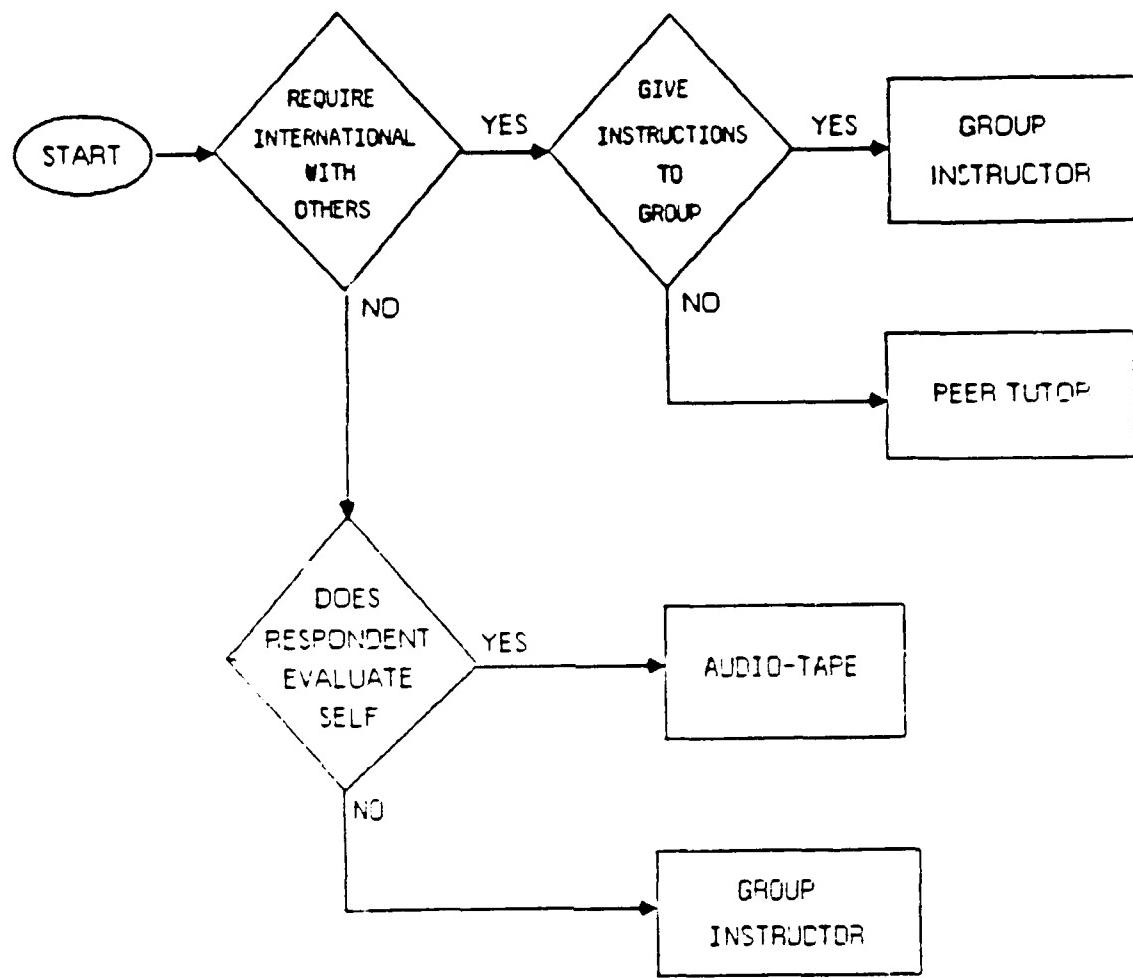


Figure B-7. Voice response

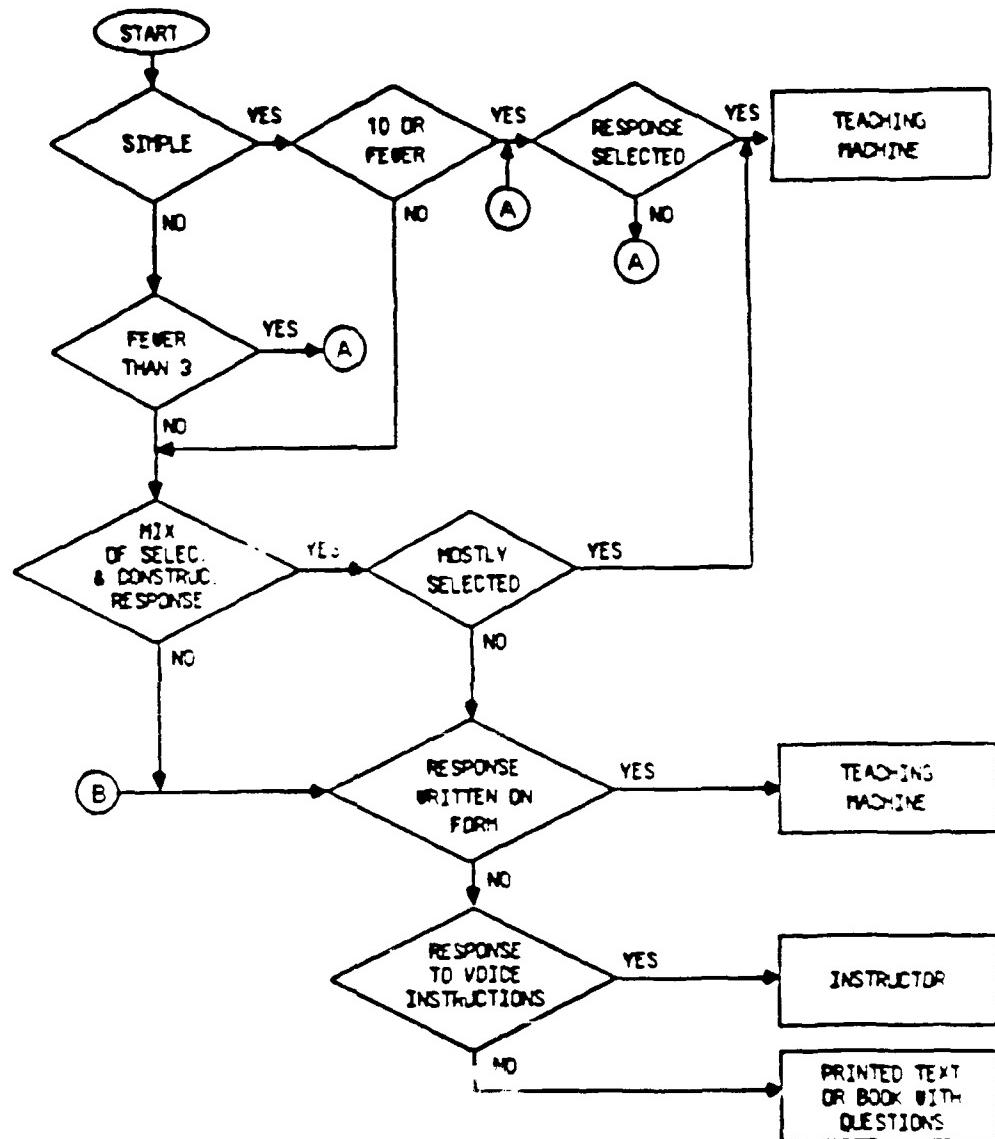


Figure B-8. Written response

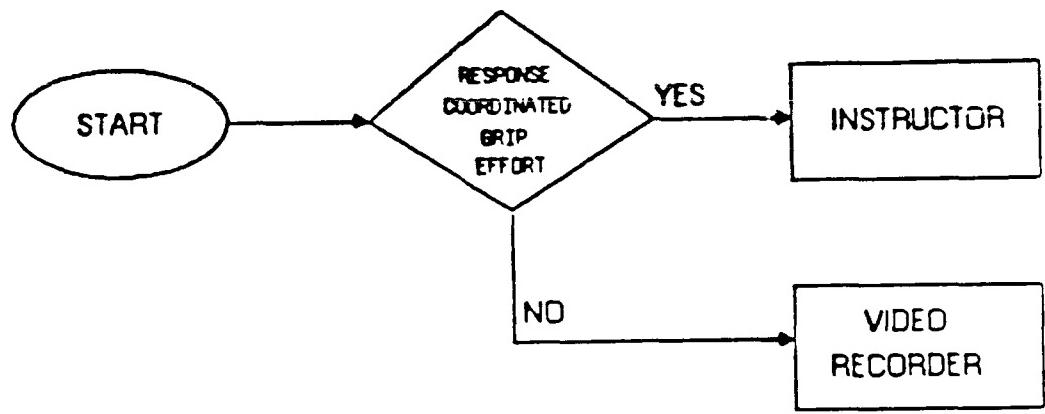


Figure B-9. Body movement

RECOMMENDED STIMULI MEDIA

| | | PRINTED MATERIAL | | | AUDIO MEDIA | | |
|-----------------------------------|--------------------------|-----------------------|------------------|------------------------|------------------------|------------------|--|
| CHARACTERISTICS | BODIES WITH QUESTIONS | PROGRAMMED TEXT | PRINTED TEXT | SILENT FILM STRIP | MOVIE | MOVIE STRIP | |
| 1 PACIFIC CONTROL | STUDENT | PROGRAM OR STUDENT | STUDENT | PROGRAM OR STUDENT | PROGRAM | PROGRAM | |
| 2 STIMULUS CONTENT | VISUAL VERBAL | VISUAL VERBAL | VISUAL VERBAL | AUDIO VISUAL VERBAL | AUDIO VISUAL VERBAL | VISUAL VERBAL | |
| 3 NEW LEARNING ACTIVITY | PROGRAM | PROGRAM | INSTRUCTOR | PROGRAM | PROGRAM | PROGRAM | |

TABLE A

REFERENCES

METHODS

| | | METHODS | | | ROLE PLAYING | | |
|-----------------------------------|---------------------------|--------------------------|--------------------|-------------------------|---------------------------|-----------------|--|
| CHARACTERISTICS | PROGRAMMED INSTRUCTION | TRADITIONAL CLASSROOM | Demon- stration | PROGRAMATIC | COOP. ASS. INSTRUCTION | ROLE PLAYING | |
| 1 PACIFIC CONTROL | STUDENT OR PROGRAM | INSTRUCTOR | INSTRUCTOR | PROGRAM OR STUDENT | PROGRAM OR STUDENT | STUDENT | |
| 2 STIMULUS CONTENT | AUDIO VERBAL | AUDIO VERBAL | VISUAL | AUDIO VISUAL TACTILE | VISUAL TACTILE | AUDIO VISUAL | |
| 3 NEW LEARNING ACTIVITY | PROGRAM | INSTRUCTOR | INSTRUCTOR | PROGRAM | PROGRAM | STUDENT | |

Figure B-10. Method selection

RECOMMENDED STIMULI MEDIA

| CHARACTERISTICS | TELEVISION | BUCK-UP | SILENT SLIDES | STUDIO SLIDES | REAL EQUIP | SIMULATOR | AUDIO TAPE |
|-------------------------|--------------|--------------|---------------|--------------------|--------------------|--------------------|--------------|
| 1 PICTIC CONTROLLER | PROGRAM | STUDENT | STUDENT | PROGRAM ON STUDENT | "STUDENT" | PROGRAM ON STUDENT | PROGRAM |
| 2 STIMULI CONTENT | AUDIO VISUAL | AUDIO VISUAL | VISUAL | VISUAL | AUDIO VISUAL | AUDIO VISUAL | AUDIO VISUAL |
| 3 NEW LEARNING ACTIVITY | PROGRAM | PROGRAM | PROGRAM | PROGRAM | PROGRAM ON STUDENT | PROGRAM | PROGRAM |

NOTES

"ALSO EQUIP DELAYS"

TABLE A (CONTINUED)

METHODS

| CHARACTERISTICS | CARDS | TUTORING | CASE STUDY | GROUP INTERVIEW | IN INDIVIDUAL EXERCISE | PEN PAPER | GUIDED DISCUSSION | STUDY ASSIGN. |
|-------------------------|--------------|--------------|------------|-----------------|------------------------|-----------|-------------------|---------------|
| 1 PICTIC CONTROLLER | STUDENT | INSTRUCTOR | STUDENT | STUDENT | STUDENT | PIER | INSTRUCTOR | STUDENT |
| 2 STIMULI CONTENT | AUDIO VISUAL | AUDIO VISUAL | VISUAL | AUDIO VISUAL | VISUAL | AUDIO | VISUAL | VISUAL |
| 3 NEW LEARNING ACTIVITY | PROGRAM | INSTRUCTOR | STUDENT | PROGRAM | STUDENT | PROGRAM | INSTRUCTOR | STUDENT |

TABLE B (continued)

Figure B-10. Method selection (continued)

RECOMMENDED RESPONSE ACCEPTANCE MECHANISMS

| PRINTED MATERIAL | | RECOMMENDED RESPONSE ACCEPTANCE MECHANISMS | | | | | |
|-----------------------------|-----------------------|--|--------------------------|-----------------------|--------------------------|--------------------------|--------------------------|
| CHARACTERISTICS | NOTES ON INSTRUCTIONS | PRINTED TEXT | GROUP INSTRUCTOR | INDIVIDUAL INSTRUCTOR | TEACHING MACHINE | REAL EQUIPMENT | SITUATION |
| 4 PRACTIC CONTROLLER | STUDENT | STUDENT | PROGRAM OR STUDENT | PROGRAM OR STUDENT | STUDENT | PROGRAM OR STUDENT | PROGRAM OR STUDENT |
| 5 TYPE EVALUATION | INDIVIDUAL "SELECTED" | INDIVIDUAL "CONSTRUCTED" | INDIVIDUAL "CONSTRUCTED" | INDIVIDUAL "SELECTED" | INDIVIDUAL "CONSTRUCTED" | INDIVIDUAL "CONSTRUCTED" | INDIVIDUAL "CONSTRUCTED" |
| 6 FEEDBACK | IMMEDIATE "INTRINSIC" | DELAYED "EXTRINSIC" | DELAYED "EXTRINSIC" | IMMEDIATE "INTRINSIC" | IMMEDIATE "INTRINSIC" | IMMEDIATE "INTRINSIC" | IMMEDIATE "INTRINSIC" |
| 7 NEXT LEARNING ACTIVITY | PROGRAM | INSTRUCTOR | PROGRAM OR STUDENT | PROGRAM OR STUDENT | INSTRUCTOR | PROGRAM | PROGRAM OR STUDENT |
| NOTES: | "CAN BE CONSTRUCTED" | "CAN BE SELECTED" | "FOR 1 N" | "IMMEDIATE 1 N" | "FOR 1 N" | "CAN BE SELECTED" | "CAN BE SELECTED" |

TABLE C

METHODS

| PROGRAMMED INSTRUCTION | | METHODS | | | | | |
|-----------------------------|-----------------------|---------------------------|---------------------------|---------------------------|---------------------------|------------------------|------------------------|
| CHARACTERISTICS | NOTES | TRANSITIONAL CLASSROOM | TRANSITIONAL INSTRUCTION | TRANSITIONAL PE | TRANSITIONAL PE | COMPUTER INSTRUCTION | COMPUTER INSTRUCTION |
| 4 PRACTIC CONTROLLER | STUDENT | PROGRAM | INSTRUCTOR | INSTRUCTOR | INSTRUCTOR | PROGRAM OR STUDENT | PROGRAM OR STUDENT |
| 5 TYPE EVALUATION | INDIVIDUAL "SELECTED" | INDIVIDUAL "SELECTED" | INDIVIDUAL "SELECTED" | INDIVIDUAL "SELECTED" | INDIVIDUAL "SELECTED" | INDIVIDUAL "SELECTED" | INDIVIDUAL "SELECTED" |
| 6 FEEDBACK | IMMEDIATE "INTRINSIC" | DELAYED "EXTRINSIC" | DELAYED "EXTRINSIC" | IMMEDIATE "INTRINSIC" | IMMEDIATE "INTRINSIC" | IMMEDIATE "INTRINSIC" | IMMEDIATE "INTRINSIC" |
| 7 NEXT LEARNING ACTIVITY | PROGRAM | INSTRUCTOR | INSTRUCTOR | INSTRUCTOR | INSTRUCTOR | PROGRAM | PROGRAM |
| NOTES: | "INDIVIDUAL FOR 1 N" | "IMMEDIATE EXTRINSIC 1 N" | "IMMEDIATE EXTRINSIC 1 N" | "IMMEDIATE EXTRINSIC 1 N" | "IMMEDIATE EXTRINSIC 1 N" | "LIMITED CONSTRUCTION" | "LIMITED CONSTRUCTION" |

TABLE D

Figure B-11. Method selection

**RECOMMENDED RESPONSE
ACCEPTANCE MECHANISMS**

| CHARACTERISTICS | VIDEO RECORDING | WORK-UP | PAPER |
|---------------------------|------------------------|------------------------|------------------------|
| PACING | STUDENT ON INSTRUCTION | STUDENT | INSTRUCTOR |
| 4. CONTROLLER | INDIVIDUAL CONSTRUCTED | INDIVIDUAL CONSTRUCTED | INDIVIDUAL CONSTRUCTED |
| 5. EVALUATION | IMMEDIATE | IMMEDIATE | IMMEDIATE |
| 6. FEEDBACK | INTRINSIC | INTRINSIC | INTRINSIC |
| 7. WEST LEARNING ACTIVITY | PROGRAM OR INSTRUCTOR | PROGRAM | INSTRUCTOR |

TABLE C (continued)

METHODS

| CHARACTERISTICS | ROLE PLAYS | CASES | TUTORING | CASE STUDY | GROUP INTERVIEW | IN-DEPTH EXPENSE | PAPER TUTOR | QUIZED TEST | STUDY ASSIGN. |
|---------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| PACING | STUDENT |
| 4. CONTROLLER | INDIVIDUAL CONSTRUCTED |
| 5. EVALUATION | IMMEDIATE |
| 6. FEEDBACK | INTRINSIC |
| 7. WEST LEARNING ACTIVITY | STUDENT | PROGRAM | INSTRUCTOR | STUDENT | STUDENT | PROGRAM | STUDENT | STUDENT | STUDENT |

* INDIVIDUAL OR GROUP

SITUATION

TABLE D (continued)

Figure B-11. Method selection (continued)

| ALGORITHMS | | | | | | | | | |
|---------------------------|---------------------------|---------------------------|------------------------|------------------------|------------------------|--------------------|--------------------|------------------------|---------------------|
| IDENTIFYING SYMBOLS | SOUND FILE STRIP | RULE USING | CLASSIFYING | DECISION MAKING | MATH SOLVING | CROSS MOTOR SKILLS | MOTOR CHAINING | COMUNICATIONS | MONITORING ATTITUDE |
| PROGRAMMED INSTRUCTION | PROGRAMMED INSTRUCTION | PROGRAMMED INSTRUCTION | PROGRAMMED INSTRUCTION | PROGRAMMED INSTRUCTION | PROGRAMMED INSTRUCTION | PROGRAMMED PI | PROGRAMMED PI | PROGRAMMED INSTRUCTION | PROGRAMMED PI |
| TRADITIONAL CLASSROOM | TRADITIONAL CLASSROOM | TRADITIONAL CLASSROOM | TRADITIONAL CLASSROOM | TRADITIONAL CLASSROOM | TRADITIONAL CLASSROOM | TRADITIONAL PI | TRADITIONAL PI | TRADITIONAL CLASSROOM | TRADITIONAL PI |
| DECODE MATERIUM | PROGRAMMED PI | COMP. ASST'D. INSTRUCTION | COMP. ASST'D. | COMP. ASST'D. | COMP. ASST'D. | ROLE PLAYING | ROLE PLAYING | ROLE PLAYING | ROLE PLAYING |
| PROGRAMMED PI | COMP. ASST'D. INSTRUCTION | IN BASED EXERCISE | ROLE PLAYING | ROLE PLAYING | ROLE PLAYING | PI | PI | PI | PI |
| COMP. ASST'D. INSTRUCTION | COMP. ASST'D. INSTRUCTION | ROLE PLAYING | CASE STUDY | CASE STUDY | CASE STUDY | DISCUSSION | DISCUSSION | STUDY ASST'D. BOOK | STUDY ASST'D. BOOK |
| TUTORING | TUTORING | NURMING | IN BASED EXERCISE | IN BASED EXERCISE | IN BASED EXERCISE | QUIZED | QUIZED | QUIZED | QUIZED |
| PEN TUTOR | PEN TUTOR | STUDY | STUDY | STUDY | STUDY | DISCUSSION | DISCUSSION | STUDY ASST'D. BOOK | STUDY ASST'D. BOOK |
| STUDY ASST'D. BOOK | STUDY ASST'D. BOOK | PI | PI | PI | PI | STUDY ASST'D. BOOK | STUDY ASST'D. BOOK | STUDY ASST'D. BOOK | STUDY ASST'D. BOOK |

Figure B-12. Algorithm-method compatibility table

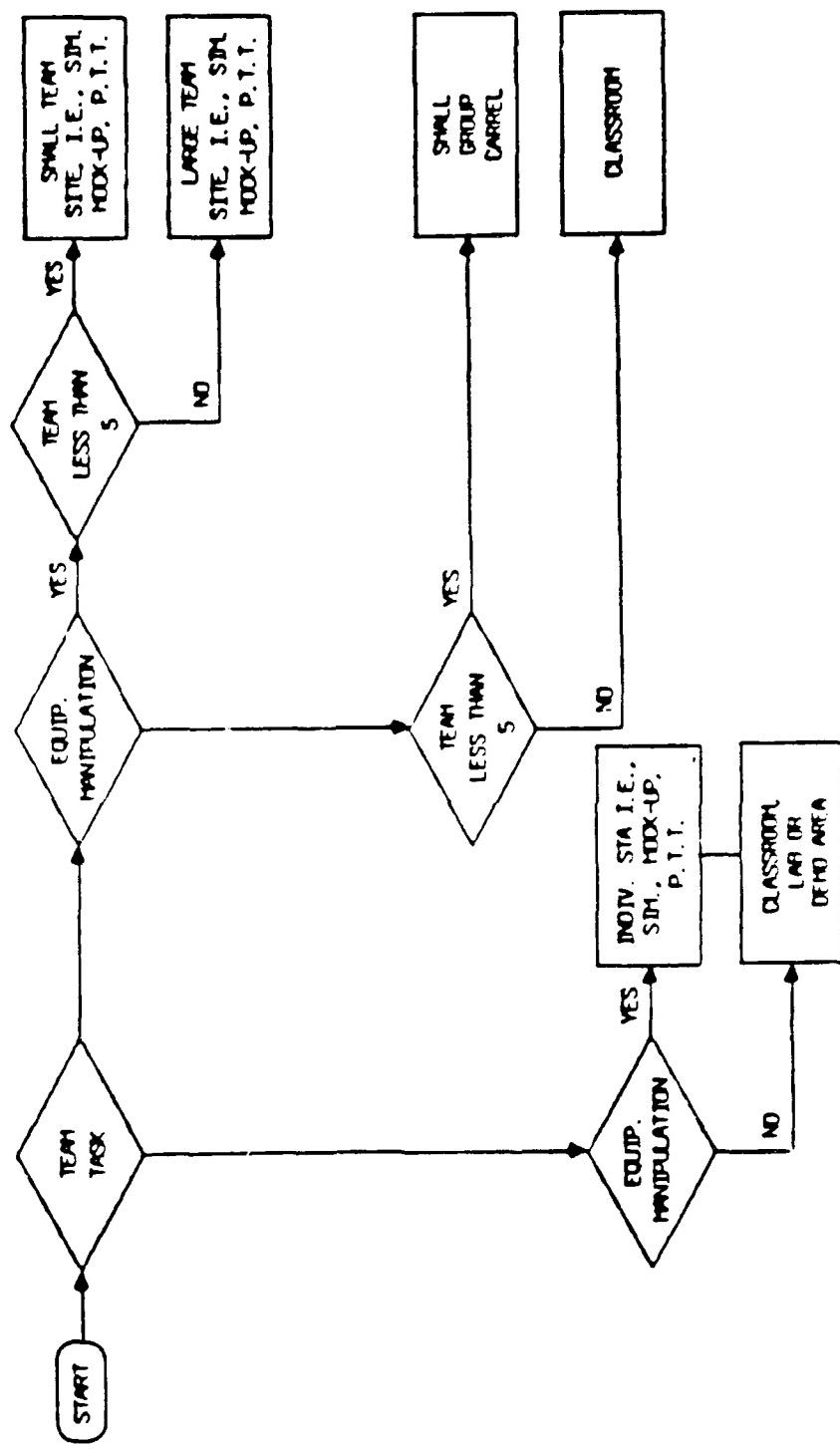


Figure B-13. Learning setting

MANPRINT METHODS MONOGRAPH:
AIDING THE DEVELOPMENT OF TRAINING CONSTRAINTS

PRODUCT 4: TRAINING CONSTRAINTS ESTIMATION AID (TCEA)

Lawrence O'Brien
Dynamics Research Corporation

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PRODUCT 4: TRAINING CONSTRAINTS ESTIMATION AID

INTRODUCTION

Objective of Paper

This concept paper describes an aid for estimating training time constraints for Army weapon systems. The Training Constraints Estimation Aid (TCEA) is one of six automated products being developed in the Army Research Institute's (ARI) Manpower, Personnel, and Training aids for the MANPRINT integration (MPT)² project.

The concept paper presents requirements for this aid, and includes a detailed description of the aid's steps, automated components, and techniques for developing them. The concept paper also outlines an approach for implementing the aid.

Organization of Paper

This concept paper has seven sections. The section of product requirements includes the product's objectives, significant output, users, role in the acquisition process, assumptions, and high-level functional requirements or constraints.

The product overview is a brief introduction to the product itself, including its output, steps the user will go through to apply the product, our product development approach, and the anticipated architecture of automated components. The section on the TCEA's steps explains the input, output, process, user interface, and development approach for each step in great detail. The next section describes the TCEA's automated components in detail. The last two sections contain technology transfer issues and the references, respectively.

This concept paper also includes several appendices. The Software Development Methodology is presented in Appendix A. Appendix B includes formats for Army Requirements Documents. Appendix C describes the process for assessing the unit training resource requirements and Training Management and Control System (TMACS), an automated system designed to assist Army analysts in this process.

We have purposely repeated material in Sections 4 and 5. We hope that this will make it easier to read each section independently.

PRODUCT REQUIREMENTS

Output

The TCEA will produce two related but distinctively different outputs. First, it will produce estimates of the maximum amount of time that will be available to train the new system in both initial institutional and unit training. Second, it will generate a set of operator and maintainer tasks for the new system and produce an estimate of the likely amount of time that will be spent in training these tasks. The estimates of maximum training time will be listed as constraints in the system specification. Contractors will be required to design a system that does not require training which exceeds these maximum constraints. The estimates of likely training time will also be provided to contractors. But they will be described as guidelines which the contractor can use in estimating the personnel characteristics requirements associated with their design. The contractors will be free to substitute other training times if they can provide a rationale for their estimate and their total training time does not exceed the maximum training time constraint.

Role of Product Output in Acquisition Process

The TCEA output described above will feed into several key acquisition documents. This section identifies and describes these documents. There are two basic types of documents that describe training constraints: Army requirements documents which are designed to guide the Army organizations in charge of developing the system, and contractor specifications which are designed to provide detailed guidance to the contractor developing the system. Both types of documents are closely related. In fact, the contractor specifications are derived from the Army requirements documents.

Army Requirements Documents

The Training Constraints Estimation Aid (TCEA) will provide input into four Army requirements documents: the Justification for Major System New Start (JMSNS), the Operations and Organizational (O&O) Plan, the Letter of Agreement (LOA), and the Required Operational Capability (ROC). The JMSNS, O&O Plan, and LOA should be produced during the Requirements/Technology Base Activities Phase of the Materiel Acquisition Phase (MAP). The ROC should be produced during the Proof-of-Principle Phase.

The requirements documents described above (JMSNS, O&O Plan, LOA, and ROC) are typically prepared by the Directorate of Combat Development (DCD) within the proponent TRADOC schools in close coordination with the Army Materiel Command (AMC) proponent.

Appendix B contains specific formats for these requirements documents. The sections below list details on how training constraints are presented in the requirements documents.

Organizational and Operational Plan. The Operational and Organizational (O&O) Plan should be developed during the Requirements Technology Base Activities Phase of the MAP. This plan describes how the new system will be integrated into the force structure, deployed, operated, and supported in both peacetime and wartime.

Training issues should be discussed in Section VI of the O&O Plan.

". . . VI Training Impact - Design of the equipment should consider type and extent of training required. (When the system is decided on, discuss the type and amount of training required and the need for training devices and simulators.) This plan will support preparation of the Training Support Plan. (DARCOM/TRADOC PAM 70-2)

AR 71-9 and DARCOM/TRADOC PAM 70-2, Chapter 3 provide guidance for preparation of the O&O plan.

Justification for Major System New Start. The Justification for Major System New Start (JMSNS) is required when the estimated cost to meet a mission need exceeds specified limits, or when other factors demand a DoD-level review. Section F requires a description of "key boundary conditions for satisfying the need, such as survivability, logistics, manpower and personnel constraints in both quantity and quality; . . ." (TRADOC PAM 70-2, p. 4.10). No explicit mention of training is listed in the JMSNS format.

Letter of Agreement. The Letter of Agreement (LOA) defines the proposed system concept and the research needed to develop and validate it. Paragraph 8 of the LOA requires a training assessment.

". . . 8. TRAINING ASSESSMENT. Discuss the planned or system training device. When required include description as an annex. New Equipment Training, operator and maintenance personnel training, and technical manuals and training material requirements will be stated in terms of needs for both the institution and unit training

levels. The training support plan will be available for evaluation during Operational Test (OT) I . . ."

Required Operational Capability. The Required Operational Capability (ROC) is a formal requirements document that "states the minimum essential . . . information necessary to initiate the Full-Scale Development Phase or procurement of a materiel system." (DARCOM/TRADOC PAM 70-2, p. 6.1). It addresses many of the same manpower, personnel, and training issues the LOA addresses, but at a lower level of detail.

The format for Paragraph 8, TRAINING ASSESSMENT, in the ROC is almost identical to Paragraph 8 in the LOA (see above). However, the ROC includes an additional requirement that the training support package be tested prior to operational test (OT) II.

In summary, current Army requirements require an early assessment of training issues. To accomplish this, an estimate of the likely training program for the new system must be identified early in the design process. None of the Army requirements documents specifically requires an assessment of training constraints.

Documents for Presenting Requirements to Contractors

The Army requirements documents described above define system performance requirements for Army organizations. However, these documents are typically not the primary mechanism for presenting requirements and constraints to contractors. The Army requirements documents may be included in the RFP package as background information, but the contractor is not contractually bound to meet the requirements in these documents. Rather, the contractor must adhere to the requirements cited in the system specification.

MIL-STD-490, completely revised in 1985, contains procedures for describing system specifications. This standard describes system specifications in increasing detail as the weapon system progresses through the MAP. The first system specification to be developed for a major weapon is the System/Segment Specification (SSS) or Type A Specification. The SSS should be initially developed during the Requirements/Technology Base Activities Phase of the MAP but may be updated in the subsequent phase. It is typically developed by the combat developer within the proponent school but may be contracted out. Data Item Description (DID) DI-CMAN-80008 describes the SSS format.

The SSS DID requires a description of "training time and locations available for an effective training program." Table 1 lists the training requirements section of that DID.

The SSS also includes a section on qualification requirements. This section describes the methods for demonstrating that each system requirement and constraint has been met.

During later phases of the MAP, more detailed system specifications are developed (see MIL-STD-490). However, because these specifications allocate functions among particular system steps, they actually describe requirements at the component level. Consequently, these specifications are not relevant to the TCEA.

Role of Training Constraints in MANPRINT

Currently, two major sources of MANPRINT regulatory information exist: AR 602-2, MANPRINT, and the draft chapter on MANPRINT that the revised TRADOC/AMC PAM 70-2, Materiel Acquisition Handbook (hereafter referred to as the Revised TRADOC/AMC PAM 70-2) will include:

Training Constraints. According to AR 602-2 (p. 28), the Proof-of-Principle Phase will accomplish the following:

". . . g. Special human factors engineering characteristics, male and female soldier characteristics, and manpower, personnel, and training considerations peculiar to the system will be addressed as specified in the requirements documents (AR 71-9). The MANPRINT portion of the requirements documents will provide soldier performance specifications and consider maximum and minimum personnel aptitudes and skill that can be required. . . ."

The revised TRADOC/AMC PAM 70-2 (p. 11.91-11.92), provides more specific guidance on the role of training constraints in MANPRINT. Table 2 lists this guidance.

The TCEA will assist Army analysts in identifying one of the key constraints listed in Table 2--namely time-to-train limits.

Table 1. Guidelines for Describing TCEA Products from
SSS DID (DI-CMAN-80008).

10.2.5.5.5 Training. This subparagraph shall be numbered 3.5.5 and specify the following training requirements:

- a. Contractor and Government responsibility for training requirements that will be generated by new equipment. This subparagraph shall also specify the concept of how training shall be accomplished (e.g., school, contractor training).
- b. Estimates of quantities of equipment being developed that will be required solely for training purposes.
- c. The need to develop associated training devices, including types required. In addition, this paragraph shall specify: (1) detailed requirements for characteristics of training devices, and (2) training and skills to be developed by training devices.
- d. Training time and locations available for an effective training program.
- e. Source material and training aids to support the specified training.
- f. Other training requirements not previously mentioned.

**Table 2. Guidance on Training Constraints from
Draft Chapter 11 of TRADOC/AMC PAM 70-2.**

EVENT 1: TRAINING CONSTRAINTS AND EARLY ANALYSIS

Description:

- a. Develop training constraints from guidance, lessons learned, Mission Area Analysis (MAA), post fielding Training Effectiveness Analysis (TEA) (TRADOC Reg 350-4), or completed Early Comparability Analysis (ECA). Participate in MANPRINT Joint Working Group (MJWG) to ensure training constraints are addressed and that sources of information are considered. Continue to work with the group as the acquisition process is executed.
- b. Accomplish training portion of ECA if not conducted as part of MAA.
- c. Provide a list of constraints (elimination of high driver tasks, time-to-train limits, requirement for simulator to meet constraints of training ammunition, POL, etc.) to Operational and Organizational (O&O) Plan, System MANPRINT Management Plan (SMMP) and as a basis for Individual and Collective Training Plan (ICTP) training concept development.
- d. Include additional constraints (communications, etc.) from supporting and other participating schools and centers.

Responsibility: Directorate of Training and Doctrine (DOTD) - New System Training Office.

Users

Overview of Users and Their Functions

Primary Users. The primary TCEA user will be the combat developers within the TRADOC proponent school who produce requirements documents for major systems (i.e., JMSNS, O&O Plan, LOA, and ROC) and the System/Segment Specification (SSS) that will guide early contractor design activities.

The organization within the proponent school that typically accomplishes these functions is the Directorate of Combat Development (DCD).

Each DCD is organized slightly differently. Portions of the requirements documents and the SSS may be completed by either a Concepts and Studies Division, Materiel Logistics Support Division, or Requirements Division within a specific DCD.

When we develop detailed specifications for the TCEA, we will identify the specific DCD organizations within each major TRADOC proponent responsible for producing requirements documents and the SSS. This will be accomplished by examining the AR 10 series for each school.

Secondary Users. Another major user group will be the Army Material Command (AMC) major subordinate command responsible for providing the TRADOC combat developer with input to requirements documents. Since each AMC major subordinate command is organized differently, the specific AMC organization that fulfills this role can vary. Again, when we develop detailed design specifications for the TCEA, we will use the AR 10 series to generate a detailed list of the responsible AMC organizations. Typically, the AMC command has an Advanced System Directorate (ASD) with a Requirements Analysis Division (RAD). The RAD is responsible for coordinating requirements documents with TRADOC. For example, according to AVSCOM Requirement 10-1 dated 5 March 1986, the Requirements analysis Division

"With support from the Advanced Concepts Division (ACD) and the Systems Technology Division (STD) on assigned projects, will maintain developer and user interface with TRADOC, FORSCOM, and their Army users and coordinate requirements documents such as O&Os, LOAs, LRs, and ROCs within AVSCOM."

Other Users. Other potential users are the personnel charged with reviewing requirements documents, including HQ TRADOC (DCSCD), HQ AMC (AMCDRE), and the Requirements Division (DAMO-FOR) within DCSOPS; the MANPRINT Policy Office within ODCSPER (DAPE-ZAM); the MANPRINT points-of-contact within the TRADOC proponent school and AMC subordinate command; and the ARI field office representatives who may provide MANPRINT support to TRADOC schools or AMC subordinate commands.

Job Type

We will develop the TCEA specifically for the primary users (listed on the previous page) -- the combat developers within the TRADOC proponent school who generate requirements documents for major systems (JMSNS, O&O Plan, LOA, and ROC) and System and Segment Specification (SSS). The individuals who actually perform these functions within the assigned DCD division are usually Army majors or captains. We will build a more definitive list of job types when we develop detailed design specifications for the TCEA. To accomplish this, we will contact the appropriate division for DCDs within the major TRADOC proponent schools.

Additional Information on Users

During the development of the detailed design specifications, we will gather additional information on (1) user training background and (2) current and projected hardware and software available to users. This information will be developed by contacting the appropriate division for DCDs for the major TRADOC proponent schools.

Assumptions

The following assumptions underly the development of the TCEA:

Major System Focus. The TCEA will describe training constraints for major weapon systems. This means that although the general logic of the TCEA could apply to other types of systems, the TCEA's automated tools will only be applicable to major systems.

Estimate Constraints Not Requirements. The TCEA will estimate training constraints based on the projections of available training resources. The TCEA will also estimate what the type and amount of training for the new system is likely to be. However, the TCEA will not estimate what the type and amount of training should be.

Input from Other Products. To estimate training resources for the new system, the TCEA must receive input on the system's expected manpower requirements. Unless otherwise directed, the TCEA will automatically use the maximum manpower constraints produced by the Manpower Constraints Estimation Aid (MCEA) as the new system's manpower requirements. However, the TCEA will be designed to allow users to enter in other assumptions about manpower requirements.

The MCEA will also identify the "source" MOSSs for the new system. These source MOSSs will describe the MOS populations from which the operators and maintainers of the new system are likely to be drawn.

Product 1, the SPREA, will provide an estimate of system requirements. The estimate will describe the overall capability, accuracy, availability, and reliability requirements for each mission, and the time and accuracy requirements for the mission's individual operational functions. We assume that these functions will be broken out to the level where they are equivalent to human operator task actions.

To estimate the number of students who must be trained in institutional training courses, the TCEA will need estimates of projected attrition and promotion rates for the new system's source MOSSs. It is assumed that these rates will be provided by Product 3. However, procedures will also be provided for using current rates obtained from DMDC data files.

Need for Unit Training Constraints. The TCEA must set training time constraints for both institutional and unit training. The reasons for this are fairly obvious. If a maximum training time constraint is set only for institutional training, the contractor could easily meet this constraint by assuming that large numbers of tasks would be trained in the unit.

Differing Units of Analyses for Unit and Institutional Training. Training time constraints will be set for each institutional course likely to be associated with the new system. However, training time constraints will be set only for the typical unit or units providing unit training. This approach is necessary because unit training varies across units, and dealing with constraints for all individual units would not be feasible.

New Equipment Training. The TCEA will not set constraints for any type of new equipment training.

Resources Available for Development. We assume that there are approximately nine person-months available for the development of detailed design specifications for the TCEA and approximately 48 person-months available for software coding.

High-Level Functional Requirements

Technical Requirements

Output. The TCEA must produce two distinct types of output. First, it must produce estimates of the maximum amount of time that will be available to train the new system in both initial institutional and unit training. Second, it must generate a set of operator and maintainer tasks for the new system and produce an estimate of the likely amount of time that will be spent in training these tasks.

Role In Acquisition Process. The TCEA information on training constraints must feed directly into Army requirements documents for major systems (JMSNS, O&O Plan, LOA, and ROC) and the Type A specification that guides contractors designs.

Users. The TCEA must be designed specifically for the combat developers within the TRADOC proponent school who produce requirements documents for major systems (JMSNS, O&O Plan, LCR, and ROC) and the Type A specification that guides early contractor design activities.

Acceptability and Usability Requirements

The previous subsection presented an overview of the technical requirements that the TCEA must meet. This section describes the acceptability and usability requirements that these tools also must meet.

Produce Tailored User Output and Processes. Often R&D products have not been implemented because they failed to meet the needs of individual Army decision makers. They were R&D products "in search of users." To avoid this problem in the current effort, we must identify specific TCEA users. Furthermore, TCEA output should be formatted so that Army users can insert them directly in MAP documents in order to meet the requirements of the new streamlined acquisition process in a timely fashion.

Describe "How To" Procedures. Whenever possible, procedures should be automated to reduce user analysis requirements. However, procedures for obtaining input data and interpreting results should be presented.

Minimize Organizational Impacts. The TCEA must be designed to fit the user and not vice versa. Consequently, the aid must not require additional personnel or cause restructuring of existing Army organizations. The TCEA must utilize computer hardware available at user locations and/or accessible via secure lines. Furthermore, it should use existing software whenever possible. If it requires new software packages, the cost of these packages must not exceed the users' typical software acquisition budget.

Minimize User Training. The members of the MAP community who are expected to be TCEA users are already overburdened and understaffed. In addition, they are trying to meet increasing acquisition requirements such as MANPRINT within the context of the streamlined acquisition process. Consequently, training time for the (MPT)² products must be minimized. This requires development of user interfaces that require no prior computer experience. For example, the interface should contain built-in job aids (e.g., help commands). Finally, when formal training is required, it must be developed in accordance with Army instructional system design principles and utilize only media that are readily available or accessible to users.

Security. Since the TCEA may be required to accept classified data, it must provide acceptable levels of security.

PRODUCT OVERVIEW

Output

The TCEA will produce two distinctively different types of output. First it will produce estimates of the maximum amount of time that will be available to train the new system. Second, it will generate a set of operator and maintainer tasks for the new system and produce estimates of the likely amount of time that will be spent in training these tasks. The maximum training time estimates will be listed as constraints in the system specification. Contractors will be required to design a system that does not require training which exceeds these maximum constraints. The estimates of likely training time will also be provided to contractors. These estimates will be described as guidelines that the contractors can use to estimate the personnel characteristic requirements associated with their design. The contractors will be free to substitute other training times, provided that they can provide a rationale for their estimate and their total training time does not exceed the maximum training time constraint.

Integration with Other (MPT)² Products

The first four (MPT)² products, the System Performance Requirements Estimation Aid (SPREA), the Manpower Constraints Estimation Aid (MCEA), the Personnel Constraints Estimation Aid (PCEA), and the Training Constraints Estimation Aid (TCEA), will estimate MPT-related requirements and constraints during the earliest phase of the acquisition process, the Requirements and Technology Base Activities Phase.

The SPREA will help Army combat developers identify comprehensive, clear system performance requirements and missions. As part of the system performance requirements, the SPREA will generate a list of the operational functions that the new system must perform. The TCEA will use these functions to generate an operator task list for the new system.

The MCEA, PCEA, and TCFA, will estimate manpower, personnel, and training constraints, respectively. The manpower constraints the MCEA produces will describe the maximum crew sizes and the maximum total number of people who will be available to man the new system. The TCEA will use the latter to determine how many people must be trained on the new system. The MCEA will also identify "source" MOSs for the new system. These are the MOSs from which the new system's operators and maintainers will probably be drawn.

The PCEA will identify the maximum level of personnel characteristics that can be supported, given the expected future distribution of these characteristics in the Army. The PCEA will also identify expected attrition and promotion rates. The TCEA will also use these rates to estimate the number of people who must be trained on the new system.

The last two (MPT)² products, the Manpower Determination Aid (MDA) and the Personnel Requirements Estimation Aid (PREA), will assist in the evaluation of contractor designs during the Proof-of-Principle Phase. The MDA will estimate the manpower requirements associated with contractor designs. The PREA will estimate the personnel characteristics required to support these designs. The likely training time estimates per task that the TCEA produces will feed both these products.

Two Types of TCEA Output

The TCEA will produce two related but distinctively different outputs: (1) estimates of maximum training time for initial institutional and unit training and (2) estimates of the likely amount of training time that will be spent in training each new system task.

Our approach for generating these two types of estimates is quite different. To estimate maximum training time, we propose to assess the resources that will be available to train the new system. To estimate likely training time, we propose to develop a prediction model that captures the current training time decision process in each mission area. The predictors in this model will be the training factors currently used to determine what tasks should be trained in institutional and unit training (for example, training difficulty, consequences of inadequate performance).

Our Approach for Estimating Maximum Training Time

Our General Approach to Constraints

The MA&D/DRC team uses the same concept of "constraint" in each of the three constraint-related MPT products (Products 2, 3, and 4). Our basic approach in these products is to estimate available resources and then to use these resources to constrain the new system design. Available resources are identified by assessing (1) the resources currently associated with the systems that the new system will replace and (2) policy or other related changes that will change what resources will be available in the

future. Each of the three constraint products estimates a different type of available resource. The MCEA (Product 2) estimates available manpower slots; the PCEA (Product 3) estimates the type of people who will be available; and the TCEA (Product 4) estimates maximum training time that can be supported, given available training resources.

Our approach to MPT constraints is directly congruent with the Army's concept of "zero sum" resourcing. This concept forces new system developers to describe specifically where (i.e., which systems or units) the resources for their new system will come from. A new system may not require more resources than the system it replaces. However, if it does, the proponent must describe the source of these resources.

How the Army Sets Training Constraints

Before discussing our approach to setting training constraints for a particular system, we will review the Army's general processes for setting institutional and unit training constraints.

Institutional Training Constraints. Institutional training requirements for a given year are reviewed during the Structured and Manning Decision Review (SMDR). The SMDR is part of the Planning, Programming, Budgeting, and Execution System (PPBES). Table 3 describes the participants in the SMDR. During the SMDR, manning and associated institutional training requirements are verified. The resulting training requirements for each course are then compared with the available training resources. Courses lacking sufficient resources to train their full training requirements are termed "constrained." These constraints are resolved by taking resources from other courses or lowering the course training requirements (lowering the number of people who must be trained). The result is a recommended training program. The final training program for a given fiscal year is published in the Army Program for Individual Training (ARPRINT).

The Army has developed an automated tool called the Army Training Requirements and Resources System (ATRRS) to assist in identifying and tracking training requirements and constraints (see AR 350-10).

ATRRS allows the Army to match and compare training requirements with training resources.

ATRRS draws information from and provides information to four levels of command:

Table 3. List of Participants in SMDR.

- (1) Office of the Deputy Chief of Staff for Military Operations and Plans (ODCSOPS)
- (2) Office of the Deputy Chief of Staff for Personnel Operations and Plans (ODCSPER)
- (3) Office of the Deputy Chief of Staff for Logistics (ODSCLOG)
- (4) National Guard Bureau (NGB)
- (5) Office of the Chief, Army Reserve (OCAR)
- (6) United States Army Military Personnel Center (MILPERCEN)
- (7) United States Army Training and Doctrine Command (TRADOC)
- (8) United States Army Recruiting Command (USAREC)
- (9) United States Army Health Services Command (HSC)
- (10) Installations where the specific courses are taught (proponent schools)

- Department of the Army Staff
- Military Personnel Center and its Reserve Component counterparts
- The Army's school systems
- The Army's schools and training centers

The ATRRS data base maintains information at the course level of detail on all courses taught by or for Army personnel. It produces reports, analyses, graphs, and selected data displays on requirements, entrants, graduates, training loads, and other related information.

One of ATRRS's major products is the ARPRINT. The ARPRINT is a major resourcing document for the U.S. Army training and Doctrine Command (TRADOC), the Surgeon General (TSG), DoD Schools, and other agencies. The ATRRS is also the basis for developing class schedules.

The ATRRS System provides accurate, timely, and responsive training input data for the PPBES. ATRRS supports the PPBES by providing information for the Army Staff to use in responding to OSD, OMB, and Congressional inquiries. A key document the ATRRS produces in support of the PPBES is the Military Manpower Training Report (MMTR). The DoD submits the MMTR to Congress to support the Army's request for authorization of student training loads in individual training.

ATRRS calculates projected training input and loads that are used as a basis for providing resources for the Army's school system. In addition, ATRRS serves as a mechanism for HQDA to correlate training requirements to the Army's recruiting objectives.

ATRRS has interactive terminals at training MACOMS, agencies, schools, and training centers throughout the Army. According to the ATRRS user's manual, ATRRS "can be run on any computer system that supports Customer Information Control System (CICS), Virtual System Access Method (VSAM), and telecommunications.

The ATRRS data base contains several data elements that are particularly relevant to the TCEA, including descriptions of institutional course lengths and the course annual trainee input capacity. The latter describes the maximum number of students that can be trained in a course, given available resources (e.g., classroom space, training facilities).

Unit Training Constraints. Each unit must pay for its own unit training by allocating resources from the Command Operating Budget (COB), which commanders use to prepare long-range plans for unit training. (For more information on the COB, see FM 25-2, Unit Training Management.) The COB is based on input from battalions and separate companies. The input is consolidated at higher levels between March and June of each year and forwarded to the Army (DA) during July. The Army has developed an automated data base called the Training Management Control System (TMACS) to assist unit commanders in estimating resource requirements for unit training events. Appendix C provides a more detailed description of TMACS and the unit training resource planning process.

Many factors limit the time spent on unit training. An ARI study by Johnson, et al. (1982) systematically identified the factors detracting from unit training in a FORSCOM infantry division. Table 4 provides a rank-ordered listing of these detractors. Within the limited time available for unit training, many requirements must be trained. System-specific and individual sustainment training are only a subset of these requirements. For example, each battalion receives a long list of directed training requirements from each of the command levels in which it is embedded. Another ARI study conducted in 1979 by Buxton, Miller, and Hayes determined the amount of time available per week for individual sustainment training in the unit. The researchers concluded that with "intensive management" only about two days per week or 100 days per year could be allotted to unit sustainment training. However, they calculated that 180 days per year were needed to meet the unit sustainment training requirements.

Unfortunately, currently no automated data base exists to describe unit training resource constraints or the actual time spent on unit training events--the key unit training data elements needed by the TCEA.

The Army's automated tool for unit training resource planning, TMACS, has several features that limit its utility for the TCEA. First, TMACS does not distinguish system-specific training events from other training events. Second, TMACS does not record information on the actual time spent on training events. Third, TMACS does not contain information on training resource constraints.

The Army Development and Employment Agency (ADEA) is developing an automated information system called the Integrated Training Management System (ITEMS). ITEMS is designed to support the integration of seven unit training management functional

**Table 4. Rank Ordering of Training Detractors
within the 71D.***

| Problem Areas | Rank |
|---------------------------------------|------|
| Shortage of NCOs and Critical MOSs | 1 |
| Turbulence | 2 |
| Personnel Shortages | 3 |
| Characteristics of Incoming Personnel | 4 |
| Time Spent In Personnel Management | 5 |
| Taskings | 6 |
| Training Management | 7 |
| Information Management | 8 |
| Administrative Tasks | 9 |
| Maintenance | 10 |
| Supply | 11 |
| Inspections | 12 |
| Inprocessing/Outprocessing | 13 |
| Redundancy | 14 |
| Schools | 15 |

*Johnson, C., Funk, S., Elliot, M., Meilza, L., & Hiller, J. (1982).

Development and implementation management innovations

(ARI Research Report 1357).

areas: (1) Requirements, (2) Calendars and Schedule, (3) Training Tempo, (4) Funds, (5) Ammunition, (6) Training Areas, Ranges, and Facilities, and (7) Training Aids and Devices. The ITEMS will contain information on the actual time spent per unit training event and should contain enough information to identify which of these events deal with system-specific training (ITEMS Data Base Specification, May 1986). The ITEMS will not describe resource constraints; however it will describe all required unit training tasks, including tasks directed by higher commands. The major limitation of the ITEMS system is that it is still in development. It is scheduled for implementation in the FY 88-90 timeframe but has undergone a number of schedule slippages.

Because of the uncertain ITEMS development schedule we have decided not to include the ITEMS as a TCEA data source.

Summary. In both institutional and unit training, the Army determines "training constraints" by looking at available resources (for example, cost, time, classroom space). As the sections that follow will demonstrate, our concept for setting maximum training time limits is directly congruent with this approach. There may be other approaches for determining maximum training time during the early phases of the acquisition process, but only a resource-based approach is likely to have meaning to the Army personnel who must actually identify training constraints early in the acquisition process.

How We Will Determine Maximum Initial Institutional Training Time

Our concept for determining maximum initial institutional training time is as follows. First, the TCEA will extract initial institutional training course information from ATRRS for all the source MOSs associated with the new system. These source MOSs, which will be identified by Product 2, will describe the MOSs from which the operators and maintainers of the new system will be drawn. The TCEA will then calculate the maximum number of training man-days that can be supported in these courses, given available resources, using the following algorithm:

$$\begin{array}{lcl} \text{Maximum} & & \text{Course Trainee} \\ \text{Available} & = & \text{Course} \times \text{Input Capacity} \\ \text{Training Day} & & \text{Length} \end{array}$$

The course trainee input capacity describes the maximum number of students that can currently be trained in a course, given available training resources.

Next the TCEA will determine the maximum length for the new system course using the following algorithm:

| Maximum Training Time | = | Available Training Days | Required Annual Student Load |
|-----------------------------|---|-------------------------------|------------------------------------|
|-----------------------------|---|-------------------------------|------------------------------------|

The required student load is the annual number of students who must be trained in each institutional training course to sustain the new system's projected manpower requirements. These estimates are determined by calculating how many people in the new system's projected manpower slots can be expected to leave those slots each year based on projected attrition and promotion rates. To estimate the new system's manpower requirements, the TCEA will use the maximum manpower constraints produced in Product 3. The result will be a worst-case estimate of student load (the user will also be given the option of inputting his or her own manpower requirement estimates). We assume that projected attrition and promotion rates will be produced by Product 2. If projected rates are not available, data on existing rates from DMDC or FORECAST can be used.

For many MOSSs, particularly many maintenance MOSSs, the institutional training course provides training on several different systems. During the application of TCEA, the user will examine the initial training Programs of Instruction (POIs) and identify the time currently spent on training weapon systems that will still be operational when the new system is fielded. This time is assumed to be a fixed constraint that the new system cannot change. The time will be subtracted from the estimated initial training course length to estimate the time that the initial training course will spend in training the new system.

How We Will Determine Maximum Unit Training Time

To estimate maximum training time per unit type, we will develop a data base called the Unit Training Time Constraint Data Base. This data base will list the maximum amount of time that different unit types are expected to have for weapon system-specific training. The estimates will be broken out by mission area and by unit location. During TCEA application, the system will link the unit types that will get the new system to the unit types in the Unit Training Time Constraint Data Base. This linkage will produce an estimate of maximum unit training time. It is assumed that Product 2 will provide a description of the unit types that will get the new system. If Product 2 does not provide this information, it should be readily available in the draft O&O Plan. In many cases, a particular unit type can be expected to operate or maintain more than one weapon system. In these cases, the TCEA will simply divide the maximum training

time estimate by the number of weapon systems expected to be operated or maintained by the unit types getting the new system.

Unfortunately, the information needed for the Unit Training Time Constraint Data Base is not available in an automated data base. To develop this information, we propose to send out a survey questionnaire to a representative sample of unit training managers. This survey will be designed to obtain all of the unit training time information for the TCEA's data bases and models. Table 5 lists the types of questions the survey will include.

The survey will be developed in accordance with state-of-the-art guidelines for mail surveys (Altschuld & Lower, 1984; Dillman, 1978; Dyer, et al., 1976; Eudos, 1983; Sudman & Bradburn, 1982; Lockhart, 1984). DRC has successfully conducted a number of surveys for ARI. These surveys include studies on the Joint Optical Information Network (JOIN) (Lockhart, 1987), Analysis of the Soldier in Europe Survey Data (Lockhart, 1987), and the user survey for the Man Integrated System Technology (MIST) (Dynamics Research Corporation, 1985).

Our Approach for Estimating Likely Training Time per Task

To estimate likely training time, we propose to develop a prediction model that captures the current training time decision process in each mission area. The predictors in this model will be the training factors currently used to determine what tasks should be trained in institutional and unit training. Before we can estimate likely training time per new system task however, we must develop a list of operator and maintainer tasks. Before we can generate this task list, we must identify the new system hardware and software. In the sections that follow, we describe our procedures for developing a generic hardware and software list for the new system and for generating a preliminary set of operator and maintainer tasks. We follow that with a description of the training time prediction model.

We have specifically attempted to develop an approach for estimating likely training time that minimizes the number of data items that must be created by the user. It is important to point out that the TCEA will be applied during the Requirements/Technology Base Activity Phase of the acquisition process. At this point in the acquisition process, the user will not have detailed information on the contractor design. Developing extensive amounts of training data for each task at this point in the acquisition process would not be efficient because it is

Table 5. Type of Questions to Be Included In Unit Training Time Survey.

| General Topic | Question Topics* | Use in TCEA | | | | | | | | | | | | |
|--|---|--|------------|------------|---|---|---|---|---|---|---|---|---|--|
| Background Information | <ul style="list-style-type: none"> - Unit Identification Code - Unit Location - Etc. | — | | | | | | | | | | | | |
| Maximum Annual Training Time | <p>Maximum time available per year</p> <ul style="list-style-type: none"> for system-specific - sustainment training - unit training | Used in the development of the Unit Training Time Constraint Data Base | | | | | | | | | | | | |
| Training Time Per Task | The annual amount of time an individual typically spends in training the following individual and collective tasks: | Used as criterion variable in regression analyses to develop unit training time prediction equations | | | | | | | | | | | | |
| Percentage Time Spent on Different Types of Training | <p>The percentage of system-specific training time using the following training types:</p> <table style="margin-left: 40px;"> <tr> <th>Type</th> <th>Individual</th> <th>Collective</th> </tr> <tr> <td>—</td> <td>—</td> <td>—</td> </tr> <tr> <td>—</td> <td>—</td> <td>—</td> </tr> <tr> <td>—</td> <td>—</td> <td>—</td> </tr> </table> | Type | Individual | Collective | — | — | — | — | — | — | — | — | — | Used in the development of the Training Type Allocation Guidelines |
| Type | Individual | Collective | | | | | | | | | | | | |
| — | — | — | | | | | | | | | | | | |
| — | — | — | | | | | | | | | | | | |
| — | — | — | | | | | | | | | | | | |

*These are not the actual questions that will be included in the survey. They are the topics that the questions will cover.

likely that large amounts of these data would have to be revised to reflect the designs eventually produced by contractors. At this point in the acquisition process, we want to provide guidance to the contractor--we do not want to develop the new system's training program.

Development of A Generic Hardware and Software List

The TCEA will help the user generate a generic hardware and software list for the new system. The TCEA will present the user with a list of the major equipment items associated with the systems to be replaced by the new system. (Product 2 will identify these replacement systems.) The user will add or delete items from this list to reflect the new system's mission, functions, and performance requirements and replace references to specific equipment items with references to generic equipment (e.g., replace reference to T999 engine with reference to diesel engine).

Development of Maintenance Task List

We assume that the three other (MPT)² products that will be applied during the Requirements/Technology Base Activities Phase will not produce a list of maintenance tasks for the new system. Product 1, the SPREA, will provide information on overall system performance requirements for both operations and maintenance. The SPREA will estimate the low-level operational functions associated with a system's mission. It is expected that these functions can be mapped onto operator task actions on a one-to-one basis. However, we believe that Product 1 will not be able to estimate low-level maintenance functions--functions at the maintenance task level. It is impossible to identify maintenance tasks until operational functions have been allocated to particular types of equipment. The performance requirements for a maintenance task, and indeed even the maintenance tasks themselves, will depend on what must be maintained. One of the requirements of Product 1 is that it must estimate functional performance requirements without any function allocation. Thus, in this context, it is unlikely that Product 1 will estimate maintenance tasks.

To produce a list of maintenance tasks, the TCEA will access the AMMDB to obtain a list of the maintenance tasks associated with the system(s) that the new system will replace. A preliminary maintenance task list for the new system will then be generated by linking the maintenance actions from the existing equipment with the new system generic equipment items. The user will then have an opportunity to review and update this list.

Development of Operator Task List

We assume that Product 1 will produce a list of operational functions. A subset of these functions is expected to be the same as operator task actions. The TCEA will present the user with an operational task action and a menu displaying the generic equipment items. The user will be asked to indicate which items on this menu will be used in performing the operational task.

The Training Time Prediction Model

To estimate training time per task, we propose to develop a prediction model that captures the current training time decision process in each mission area. The model will contain a set of regression equations that predict training time per task as a function of a set of "training factors." The training factors will attempt to represent the variables actually used by training developers to determine the time to train each task in institutional and unit training. With this in mind, we propose to use the same nine training factors the Army currently uses to determine what tasks should be trained in institutional and unit training. These factors are:

- 1) Percent of members performing
- 2) Average percent of time spent by members performing
- 3) Task learning difficulty
- 4) Consequences of inadequate performance
- 5) Task delay tolerance
- 6) Probability of deficient performance
- 7) Immediacy of performance
- 8) Relative frequency
- 9) Training emphasis

These nine factors are often combined to estimate the training "criticality" of each task. Ratings on these training factors are collected as part of The Army Occupational Survey Program (AOOSP). The AOOSP maintains a large data base of these factor ratings for individual tasks.

Many different training factors could be used in the training time prediction model. Some would argue that there are even better factors than the ones the AOOSP uses. However, in this portion of the TCEA we are attempting to estimate what the training time for the new system tasks is likely to be, not what it should be. Thus, the TCEA uses the training factors that the Army training analysts are likely to use.

Description of AOSP Training Factors. The Army Occupational Survey Program (AOSP) has routinely collected training factor data for enlisted MOSs since 1981. The primary purpose of collecting the training factor data is to help training course developers decide which tasks should be trained (either in institutional training or in supervised on-the-job unit training). Eight of the nine factors used in this decision process are derived from the Instructional System Development eight-factor model for making training decisions. The ninth factor, training emphasis, is derived from recent Air Force research on training task selection. (This research is discussed below.)

Training factor data are stored in the automated Comprehensive Occupational Data Analysis Programs (CODAP) data bases.

A recent study by Goldman (1985) assessed the reliability of the nine training factor scales and examined their success in predicting what tasks were actually trained (which AOSP tasks were actually designated critical and included in the Soldier's Manual). Goldman found that the training factors were highly intercorrelated and that only two factors, training emphasis and consequences of inadequate performance, were needed to predict which tasks were critical. These results parallel results from a previous Air Force occupational survey study by Ruck, Thompson, Brown, & Stacey (1978).

The results of Goldman and Ruck, et al. are encouraging because they suggest that only a few of the training factors may be needed to predict training time (at least for institutional training). Using fewer factors is desirable because it would reduce the size of the TCEA data bases and user input requirements.

Development of the Training Time Prediction Models. To develop the training time prediction equations, a series of regression analyses will be conducted during TCEA development using the training factors as predictors and the time to train a task as a criterion. Separate equations will be developed to predict institutional and unit training time within each mission area.

To develop the data for the regression analyses, we will select a sample of tasks for each mission area from the CODAP data base. Data on the nine training factors will be extracted from this data base. We will also obtain data on the time spent training the tasks in initial training by examining the POI for the initial institutional training course. (The Trainer's Guide for the MOS associated with the task identifies this course.)

Estimates of the annual amount of time spent in unit training will be obtained from a survey questionnaire sent to unit training managers. This survey will also be used to determine the maximum time available to train all system tasks. A more detailed description of the procedures that will be employed in this survey appears in the section entitled MA&D/DRC Approach for Development, p. 51.

Once data on training time have been collected, a series of step-wise regression analyses will be conducted using the training factor variables as predictors and the unit and institutional training time measures as criterion variables. In conducting the regression analyses, we will attempt to identify the minimum number of training factor variables needed to predict training time for each mission area. By minimizing the number of training factor variables, we can reduce the number of ratings which must be provided by users.

Application of the Training Time Prediction Equations. The TCEA will assist the user in inputting data on the training factors which are included in the training prediction model. Once these data are entered, the TCEA will apply the regression equations to predict institutional and unit training time.

To assist the user in developing the training factor scores, the TCEA will help the user identify "similar" tasks which already have training factor ratings. The TCEA will extract these ratings from CODAP and store them in an on-line data base called the Training Factor Rating Data Base. The system will automatically identify a "similar" task based on similarities of task action and noun statements to categories in Task and Equipment Taxonomies. The user can review or modify this assignment or select another task from the Training Factor Rating Data Base. Finally, the user will be able to review the training factor ratings associated with the similar tasks and update them to reflect the new system's equipment design and system performance requirements.

Breaking Out Likely Training Time Estimates among Training Types

In addition to estimating the total amount of time likely to be spent training a task, the TCEA will also determine the amount of time spent training a task using different "types" of training. Different categories of training types will be used to characterize initial institutional and unit training.

In initial institutional training, "training type" will refer to different methods and media. To describe training methods we will use the taxonomy of training methods TRADOC uses

in its POIs. We will use the taxonomy displayed in Table 6 to describe training media. This taxonomy primarily distinguishes between different types of training devices. We propose this approach because training devices are the most costly media and have had the biggest demonstrated impact on training task performance.

In unit training, "training types" will refer to (a) training level -- either individual sustainment training or collective training, and (b) type of training media. The same media categories used for institutional training will be used for unit training.

Our Approach for Resolving Differences Between Maximum Available Training Time and Estimated Likely Training Time

The TCEA will aggregate the likely training time estimates for each task to produce estimates of total likely training time for each MOS. Separate estimates will be developed for institutional and unit training. These times will be compared to the maximum time constraints. A report will be generated listing the MOSs that have shortfalls (have estimated training times that exceed the maximum time available). The report will also describe the size of the shortfall and the associated maximum and likely training time estimates.

The TCEA will then present the user with a prioritized list of the input parameters that can be changed to eliminate a training time shortfall. The user will select the parameters to be modified. The TCEA will then guide the user through the steps needed to enter new values for these parameters and calculate their impact of training time shortfalls.

Steps

Applying the TCEA involves 14 steps. The first six steps estimate maximum training time for initial institutional and unit training. The next six steps estimate the likely training time for each generic new system task. In the last two steps, the likely training times are combined and compared with the maximum training time constraints, shortfalls are identified, and TCEA steps are iterated until the shortfalls are eliminated.

Steps Involved in Estimating Maximum Training Time

Figure 2 provides an overview of the six steps the user will go through to generate maximum training time estimates.

Table 6. Example of Media Types*

Armor

Conduct-of-Fire Trainers
Tank Trainers (Driving/Gunnery/Turret)
Tracked Vehicle Driving Trainer

Weapons & Ordnance

Firing Simulator Systems

Signal

Countermeasures Training Signal Transmitting Set
Digital Computer Trainer

Aviation

Flight Simulator
Composite Trainer
Armament Systems Trainer
Hydraulic & Electrical Systems Trainer
Flight Control System Trainer
Panel Trainers
Instrument & Display Trainers
Radar Operator & Target Simulator
Power Plant/Drive System Trainers
Ejection Seat Trainer
Cockpit Procedures Trainers

Air Defense Artillery

Armament Maintenance Trainer
Guided Missile Intercept - Aerial Trainer
Guided Missile System Radar Signal Simulator

Field Artillery

Field Artillery Trainer
Programmer - Test Station

Operational Equipment

*Derived from DA PAM 310-12 Index and Description of Army Training Devices

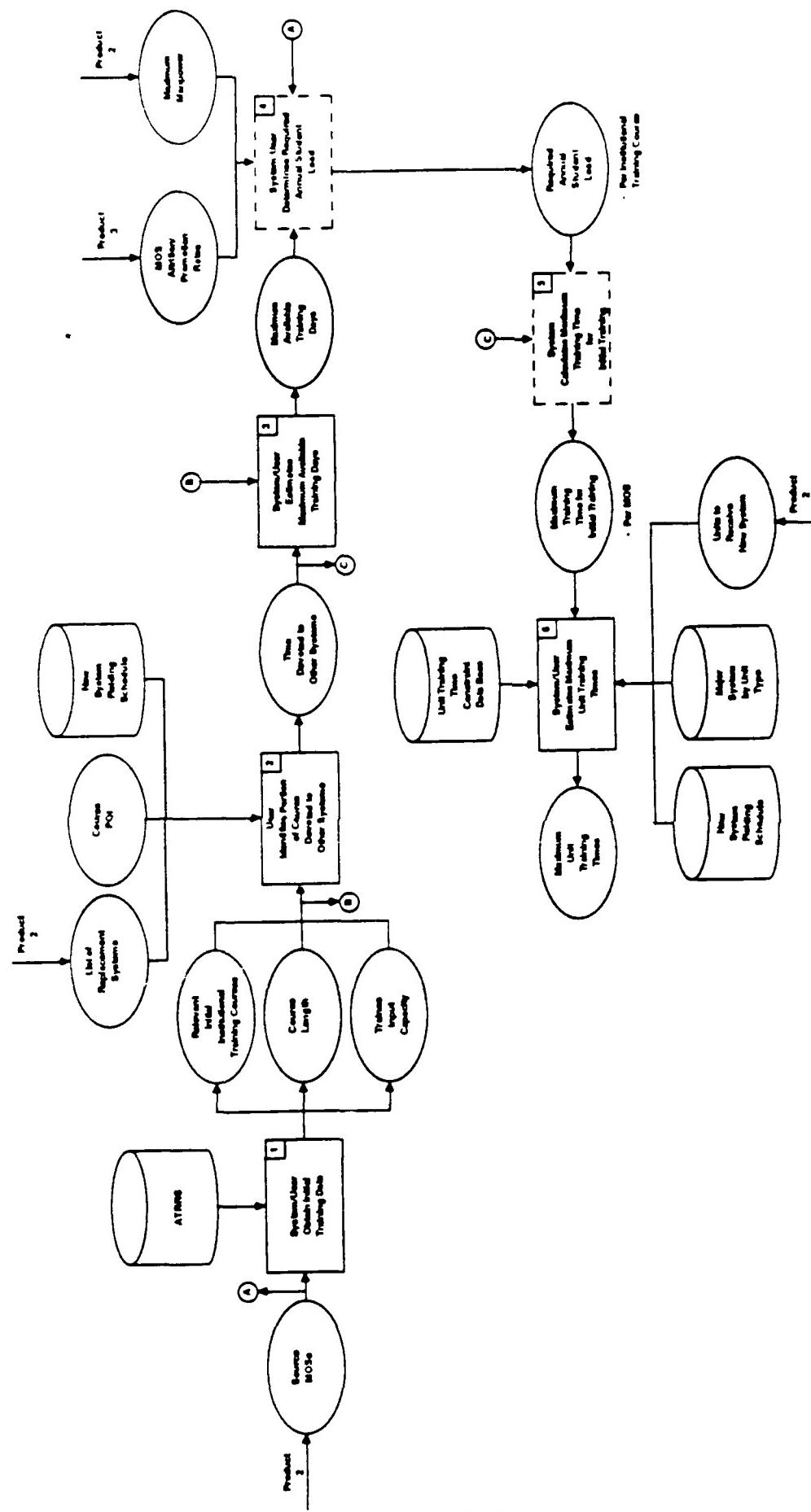


Figure 1. Steps Involved in Estimating Maximum Training Time.

During the first of these steps, the TCEA will extract institutional training course data from the Army Training Requirements and Resources System (ATRRS). These data will include (a) a list of the initial institutional training courses associated with the MOSs from which the operators and maintainers of the new system will be drawn, (b) the length of these courses, and (c) the course trainee input capacity.

During the second step, the user will examine the initial training POIs and identify the time that is currently spent on training weapon systems that are expected to be operational at the same time as the new system. This time is assumed to be a fixed constraint that cannot be changed by the new system. (In Step 5, this time will be subtracted from the estimated initial training course length to produce an estimate of the time that will be spent training the new system in the initial training course.)

During the third step, the system will estimate the maximum available training man-days for each institutional training course by multiplying the course length by the training input capacity.

In the fourth step, the TCEA will estimate the annual number of students who must be trained in each institutional training course in order to sustain the new system's manpower requirements. These estimates are determined by calculating how many people in the new system's projected manpower slots can be expected to leave those slots each year based on projected attrition and promotion rates.

The fifth step will produce estimates of maximum training time for the initial institutional training courses associated with the new system's source MOSs (the MOSs from which the new system's operators and maintainers will be drawn). To do this, the TCEA will divide the available training days by the required annual student load.

The sixth step will produce an estimate of the maximum amount of time likely to be available to train the new system in each of the unit types that are expected to get the new system. These estimates will be derived from information contained in the Unit Training Time Constraint Data Base.

Steps Involved In Estimating Likely Training Time

Steps 7 through 12 will generate a set of operator and maintainer tasks for the new system and produce estimates of the likely training time for each of these tasks (see Figure 2).

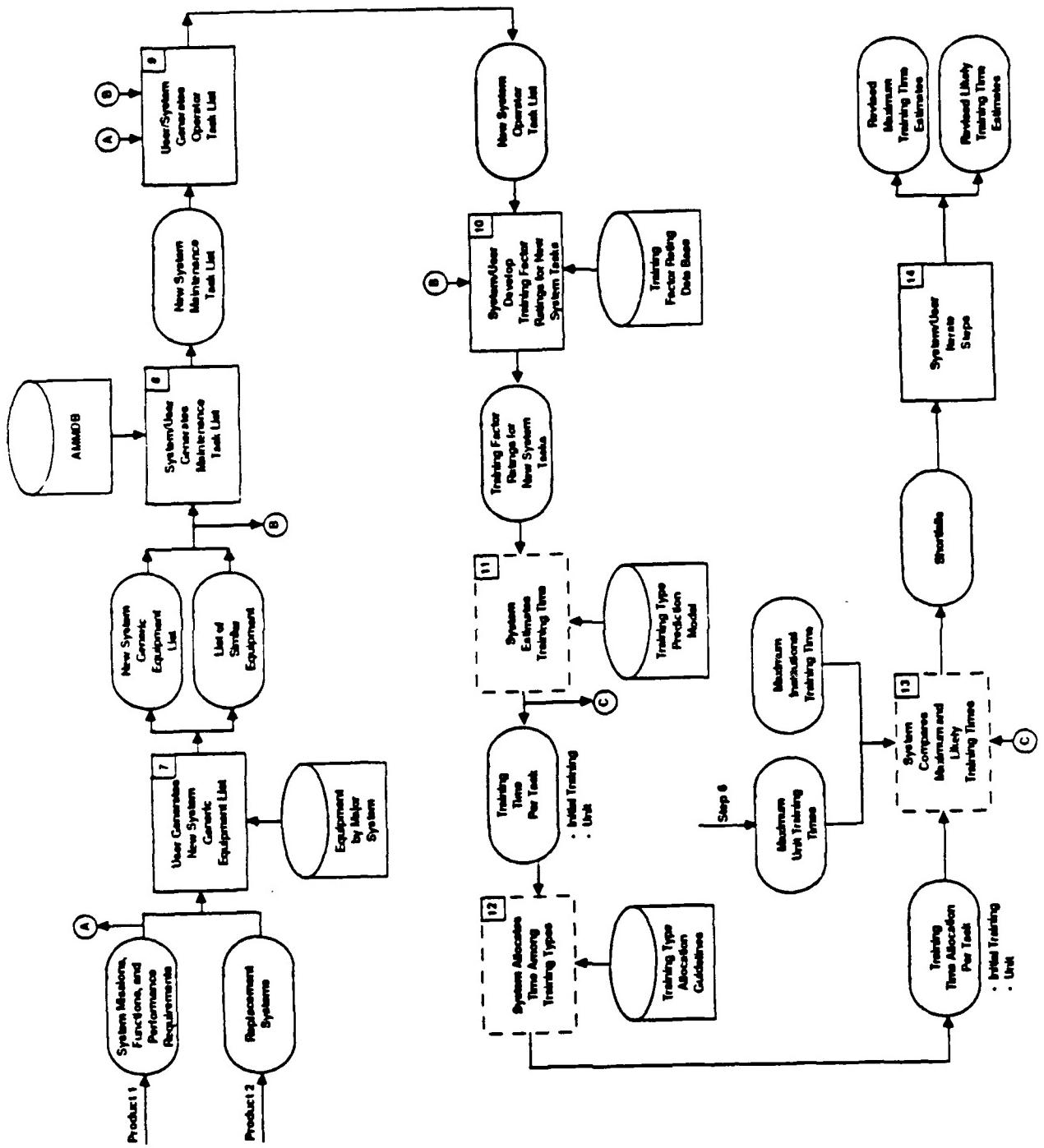


Figure 2. System/User Iterates Steps

In the seventh step, the user will generate a generic equipment list for the new system. To do this, the user will (1) review the list of major equipment items associated with the replacement system, (2) add or delete items from this list to reflect the new system's mission, functions, and performance requirements, and (3) replace references to specific equipment items with references to generic equipment (e.g., replace reference to T999 engine with reference to diesel engine).

In the eighth step, a maintenance task list will be generated for the new system. The TCEA will create a preliminary list of maintenance task statements by combining the equipment items from the generic equipment list with task actions obtained from the AMMDB for similar existing equipment. The user will then have the opportunity to review and modify these task statements.

In the ninth step, an operator task list will be generated for the new system by linking the operational tasks produced by Product 1 with generic equipment items identified in Step 7.

In the tenth step, a set of training factor ratings will be produced for each new system task. The TCEA will assist the user in identifying a similar existing task that has training factor data. The user will then review and modify these training factor data to reflect the new system's performance requirements and expected equipment design.

In the eleventh step, the TCEA will estimate the likely amount of time that will be spent in training each new system task. The TCEA software will apply a model that predicts training time as a function of the nine training factors the Army currently uses to determine task criticality.

In the twelfth step, the TCEA will estimate the amount of time the different types of training are used to train each new system task in both institutional and unit training. An on-line data base called the Training Type Allocation Guidelines will describe the estimated percentage of time that each type of training can be expected to be used in a mission area. Separate guidelines will be provided for institutional and unit training. The TCEA will apply these percentages to the total training time estimates for Step 12 to produce estimates of the time spent on each institutional and unit training type.

Steps Involved in Comparing Maximum and Likely Training Time

In the last two TCEA steps, maximum and likely training time are compared, and the TCEA is iterated until all training time

shortfalls have been eliminated (see Figure 2). In the thirteenth step, the system will compare estimated training time to the maximum training time constraint and identify shortfalls (cases where the estimated training time exceeds the maximum available training time). Separate estimates will be made for the initial institutional and unit training.

In the fourteenth step, the user will change key parameters and iterate the TCEA steps until training time shortfalls have been eliminated.

STEPS IN APPLYING TCEA

This section presents a discussion of the steps that the analyst will take in applying TCEA.

The discussion of each step is organized as follows:

1. Input - the data that are required for the completion of this step. Input data consists of two types:
 - External - input supplied by the user or sources external to the TCEA or other (MPT)² aids
 - Internal - data supplied by sources within the TCEA or other (MPT)² aids.
2. Process - the substeps that the analyst will apply during this step
3. Output - the data that will be generated as a result of this step
4. MA&D/DRC Approach for Development - our approach for developing the automated components associated with the step

There are fourteen steps in applying the TCEA. The first six steps produce estimates of maximum training time for initial institutional and unit training. The next six steps produce an estimate of the likely training time for each generic new system task. In the last two steps, the likely training times are compared to the maximum training times, shortfalls are identified, and the TCEA steps are iterated until shortfalls are eliminated. In the fourteenth step, the user can make changes to key parameters and iterate the first thirteen steps until these shortfalls are eliminated. Figure 3 provides an overview of the first six steps while Figure 4 provides an overview of the last eight steps.

We have purposely repeated information in Sections 4 and 5. We hope doing this will make it easier to read each section independently.

Step 1: System/User Obtain Initial Institutional Training Course Data

Output

During this step, the system will extract institutional training course data from the Army Training Requirements and Resources System (ATRRS). These data will include (a) a list of

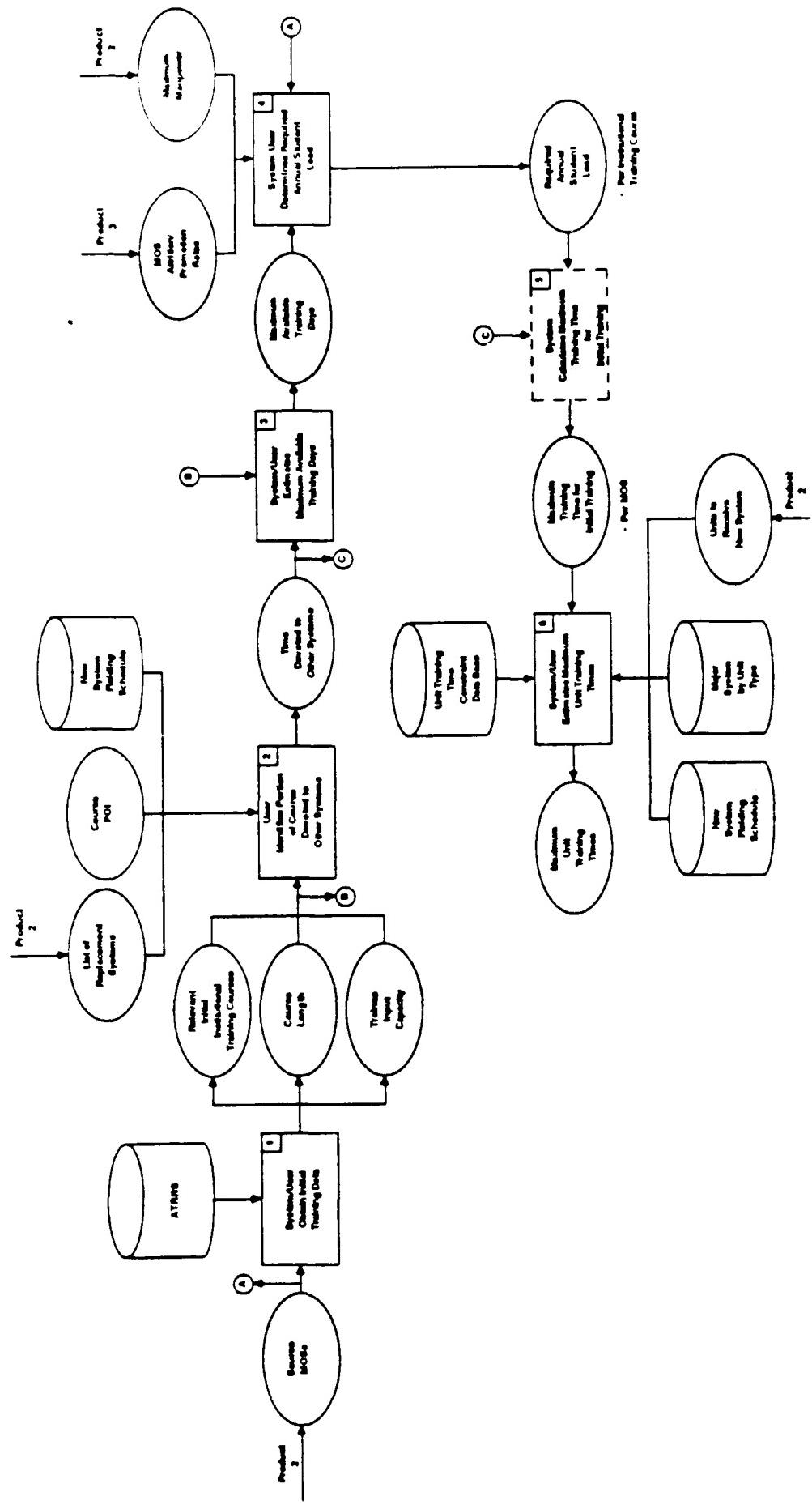


Figure 3. Steps Involved In Estimating Maximum Training Time.

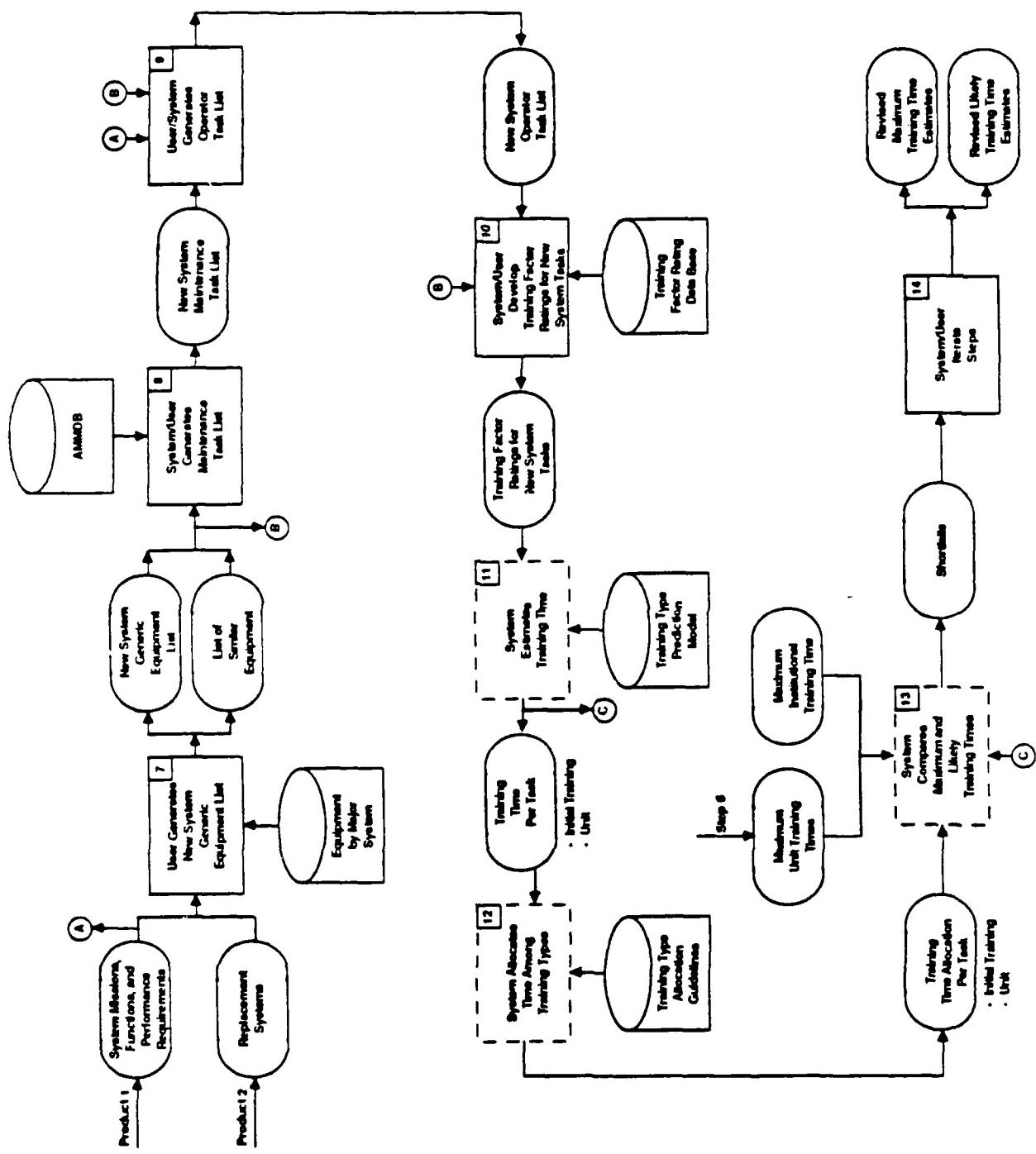


Figure 4. System/User Iterates Steps

the initial institutional training courses associated with the MOSs from which the operators and maintainers of the new system will be drawn, (b) the length of these courses, and (c) the course trainee input capacity. The course trainee input capacity describes the maximum amount of students that can be trained in a course given available training resources. The information obtained in this step will be used in subsequent steps to estimate maximum available training days for the initial institutional training courses.

Input

External Input. The user will be able to examine and modify the information on course length and input capacity obtained from ATRRS. This will give the user an opportunity to assess the impact of changes in these two variables on maximum training time.

Internal Input. Product 2 will provide a listing of the source MOSs for the new system. These MOSs will describe the likely MOS populations from which the operators and maintainers of the new system will be drawn.

Process

The user will log-on, call up the TCEA, and tell it to begin the analysis. Using the MOS list produced by Product 2 as a key, the system will call up and search through the Army Training Requirements and Resources System (ATRRS) to identify the initial institutional training course associated with each MOS. The system will use a modem to call up the ATRRS. Then the system will enter and execute a data extraction program on the ATRRS host computer. This program will place the extracted data on a flat file and send it back to the user's computer. It may take the TCEA a few minutes to make these data extractions. A message will appear on the screen which tells the user that data extractions are being made and which estimates when they will be completed. Once the data extractions have been made the user can review and modify the data on course length and trainee input capacity.

MA&D/DRC Approach for Development

All software for the TCEA will be developed in accordance with the software development methodology described in Appendix A and the user interface guidelines described in the Product Requirements Section "Description and Development of Automated Components" p. 74.

Development of ATRRS Data Extraction Program. The program for extracting information from ATRRS will present no major technical problems. DRC already has the ATRRS user's manuals and the ATRRS data element description. The specific data elements for which we will extract data are MOS (data element E-YY), course number (CRS-NO), course title (CRS-TITLE), course annual student/trainee input capacity (ANN-CAP), and course length in days (CRS-DAYS). The course number code can be used to identify which course is an initial training course.

Step 2: User Identifies Portion of Each Course Devoted to Other Systems

Output

Many initial training courses, particularly those for maintenance MOSSs, provide training on a wide range of systems. During this step, the user will examine the initial training POIs and identify the time spent on training other weapon systems that are still operational when the new system is fielded. This training time is assumed to be a fixed constraint which the new system cannot change. In Step 5, this training time will be subtracted from the estimated initial training course length to produce an estimate of the time that will be spent in training the new system in the initial training course.

Input

External Input. The user must examine the initial training POIs to determine the amount of time devoted to training different systems.

Internal Input. Product 2 will provide a list of the systems which will be replaced by the new system. An on-line data base, called the New System Fielding Schedule, will describe the major new weapon systems expected to be fielded in each mission area, the systems they will replace, and the date they are expected to be fielded.

Process

The system will produce a hard copy report listing (a) the initial training courses associated with each new system source MOS, (b) the existing systems which the new system will replace, and (c) the New System Fielding Schedule. Using this report as input, the user will review the initial institutional training POI and describe the amount of time spent on training other weapon systems that are still operational when the new system is fielded.

MA&D/DRC Approach for Development

Development of New System Fielding Schedule. The New System Fielding Schedule will describe the major new weapon systems which are expected to be fielded in each mission area, the systems they will replace, and the date they are expected to be fielded. All of the information needed to produce the New System Fielding Schedule is available in the Army Modernization Improvement Memorandum. We will simply review this data and place it in the data base.

Step 3: System Estimates Maximum Available Training Days

Output

During this step, the system will estimate the maximum available training mandays for each institutional training course. This will be accomplished using the following algorithm:

$$\begin{array}{l} \text{Maximum} \quad \text{Current} \quad \text{Course Trainee} \\ \text{Available} = \text{Course} \quad \times \quad \text{Input Capacity} \\ \text{Tr. Days} \quad \text{Length} \end{array}$$

Information on course length and course trainee input capacity will be obtained from ATRRS during Step 1. The course trainee input capacity describes the maximum amount of students that can be trained in a course given available training resources.

Input

External Input. None. This step is completely automated.

Internal Input. Step 1 will provide information on course length and course trainee input capacity for all initial institutional training courses associated with the new system.

Process

The system will simply multiply course length by trainee input capacity to produce an estimate of the maximum available training mandays for initial institutional training.

MA&D/DRC Approach for Development

Development of the software associated with this step will present no major technical problems.

Step 4: System Determines Required Annual Student Load

Output

The output of this step is estimates of the annual number of students who must be trained in each institutional training course in order to sustain the new system manpower requirements. These estimates are determined by calculating how many people in the new system's projected manpower slots can be expected to leave those slots each year. The training system must train people to replace them.

Input

External Input. The user will have the option of either using the maximum manpower constraints produced by Product 1 as an estimate of the manpower requirements for the new system, or inputting his or her own estimate of these requirements. Potential data sources for manpower requirements estimates include MAA results and the results of feasibility studies conducted during the Requirements/Technology Base Activities Phase. The user may also want to simply input a "best guess" of manpower requirements. Users will be encouraged to use the manpower constraints as the value for manpower requirements, since it will produce a worst-case estimate of maximum training time.

Internal Input. Product 2 will provide a list of the source MOSs and paygrades for the new system. Product 3 will provide an estimate of the projected attrition/promotion/MOS migration rates for these same MOSs.

Process

Figure 5 provides an overview of the process for this step. The user begins by selecting which option he or she will use to define manpower requirements for the new system -- the maximum manpower constraints from Product 2 or the user's own estimate of these requirements. If the user selects the constraint option, the system will extract the maximum manpower constraints from output files created by Product 2. If the user decides to enter his or her own estimates of manpower requirements, he or she will be presented with an input form listing the MOSs and paygrades that require manpower requirements. (These will be determined by Product 2.)

Once manpower requirements have been determined, the system will determine the estimated annual loss rate for paygrades 1 to

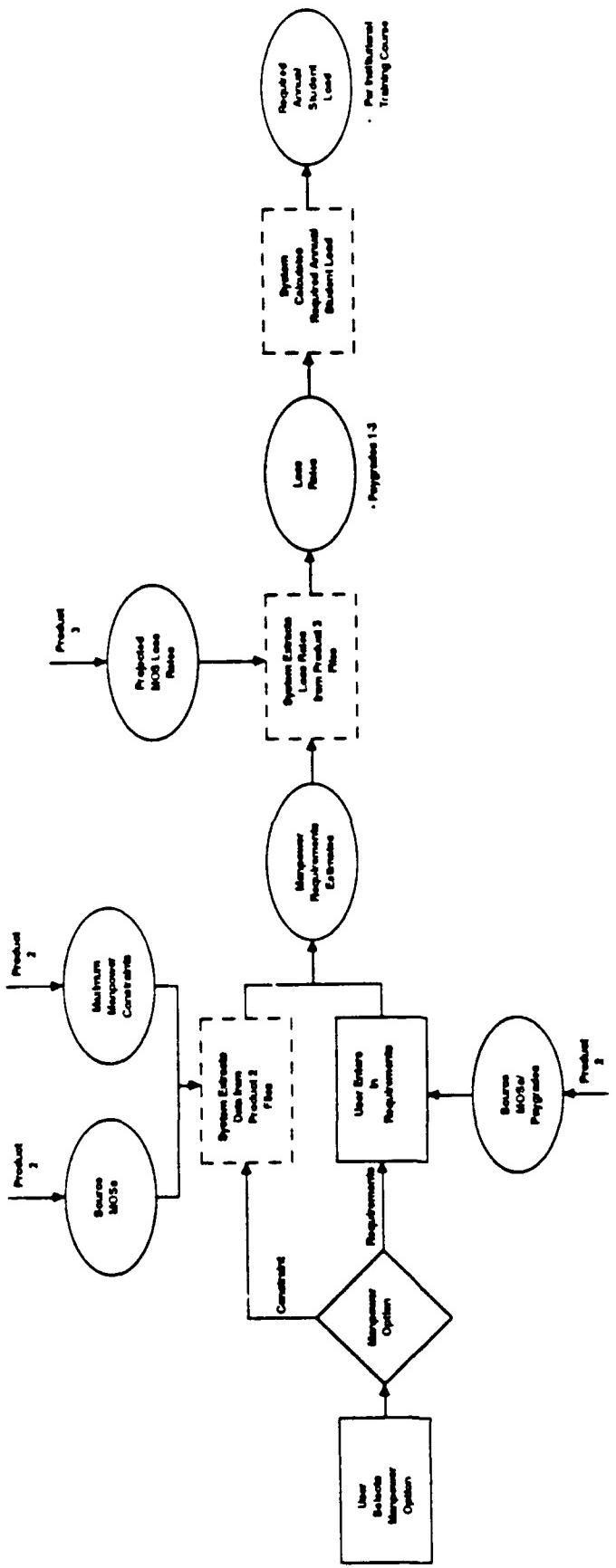


Figure 5. Overview of Logic for Determining Annual Required Student Load.

3 for each MOS by extracting this information from files created by Product 3. The system will then calculate the combined loss rate for these paygrades 1 to 3. Loss rates are calculated for personnel in these paygrades only since these are the personnel whose replacements must be trained in initial institutional training. Of course this approach assumes that the grade structure for an MOS has been developed in accordance with approved standards of grade. This insures that there will be the proper number of people at the lower paygrades to feed the manpower slot at the upper paygrades. The manpower constraints produced by our Product 2 will be developed in accordance with the standards of grade.

In the final substep, the system will calculate the required annual load for each initial institutional training course by multiplying the manpower requirements for paygrades 1 to 3 in an MOS by the expected annual loss rate for those paygrades.

MA&D/DRC Approach for Development

Development of Projected Loss Rates. We assume that projected loss rates for each of the new system's source MOSs and paygrades will be determined by Product 3. Product 3 will use these rates to develop estimates of the expected future distributions of key personnel characteristics within each source MOS. If Product 3 does not produce these loss rates, we propose to use the existing attrition and promotion rates in the calculation of student load. Information on current loss rates can be obtained directly from DMDC data files or from the FORECAST system data bases. DRC already receives tape extracts of DMDC loss files and has developed several programs for extracting data from them.

Step 5: System Calculates Maximum Training Time for Initial Training

Output

This step will produce estimates of maximum training time for the initial institutional training courses associated with the new system's source MOSs (that is, the MOSs from which the operators and maintainers of the new system will be drawn). These estimates will be determined by applying the following simple equation:

$$\text{Maximum Training Time} = \frac{\text{Available Training Days}}{\text{Required Annual Student Load}}$$

Input

External Input. None. This step will be completely automated.

Internal Input. Step 3 will provide input on the maximum available training days for the institutional training courses. Step 4 will provide input on the annual student load required to support the new system. Step 2 will provide input on the amount of time that must be spent on training other systems in the source MOS institutional training courses.

Process

The system will divide the available training days by the required annual student load to produce an initial estimate of maximum training time for each course. The time required to train other weapon systems (produced by Product 2) will be subtracted from the initial estimate to provide an estimate of the total amount of time that will be spent in training the new system.

MA&D/DRC Approach for Development

Development of the software associated with this step will present no technical problems.

Step 6: System Estimates Maximum Unit Training Times

Output

This step will produce an estimate of the maximum amount of time available to train the new system in each of the unit types expected to get the new system. The user can break out separate estimates for the locations (i.e., CONUS, Europe, etc.) expected to get the new system.

Input

External Input. If the user wants separate training time estimates for different locations, he or she must identify these locations and indicate which unit types will be assigned to each location.

Internal Input. Product 2 will provide a list of the types of units that will get the new system, the maximum crew size, and the number of crews per unit type.

Three on-line data bases will provide input to this step. The Unit Training Time Constraint data base will list the maximum amount of time that different types of units are expected to have to devote to weapon system-specific training. The estimates will be broken out by mission area and by unit location.

The New System Fielding Schedule, developed in Step 2, will describe the major new weapon systems expected to be fielded in each mission area, the systems they will replace, and the date they are expected to be fielded.

The Major System by Unit Data Base will list the major systems associated with different unit types.

Process

Figure 6 provides an overview of this process. The system will present the user with a list of the type of units to get the new system. The user will indicate whether he or she wants to break out the unit training time estimates by location. If so, the user will list the locations associated with each unit. If not, or if all required unit location information has been entered, the user will estimate the number of different weapon systems that will be trained in the units getting the new system. The user can examine the New System Fielding Schedule, which will describe the major new weapon systems which will be fielded in each mission area and the systems they will replace, and the Major System by Unit Data Base which will list the major systems associated with different unit types.

In the final substep, the system will extract data from the Unit Training Time Constraint Data Base, which will describe the maximum amount of time that can be spent on system-specific training for the unit types getting the new system. The system will then divide this time by the estimated number of weapon systems to be trained in those unit types. This will produce estimates of the maximum total amount of time that can be spent in unit training for the new system for all students. This system will then multiply the maximum crew size by number of crews per unit type. (Both of these values will be supplied by Product 2.) This will produce an estimate of the total number of soldiers who must be trained in the unit. This number will be divided into the maximum total amount of time for all students to produce an estimate of maximum time per student.

MA&D/DRC Approach for Development

Development of the Unit Training Time Constraint Data Base. The Unit Training Time Constraint Data Base will list the maximum amount of time that different types of units are expected to

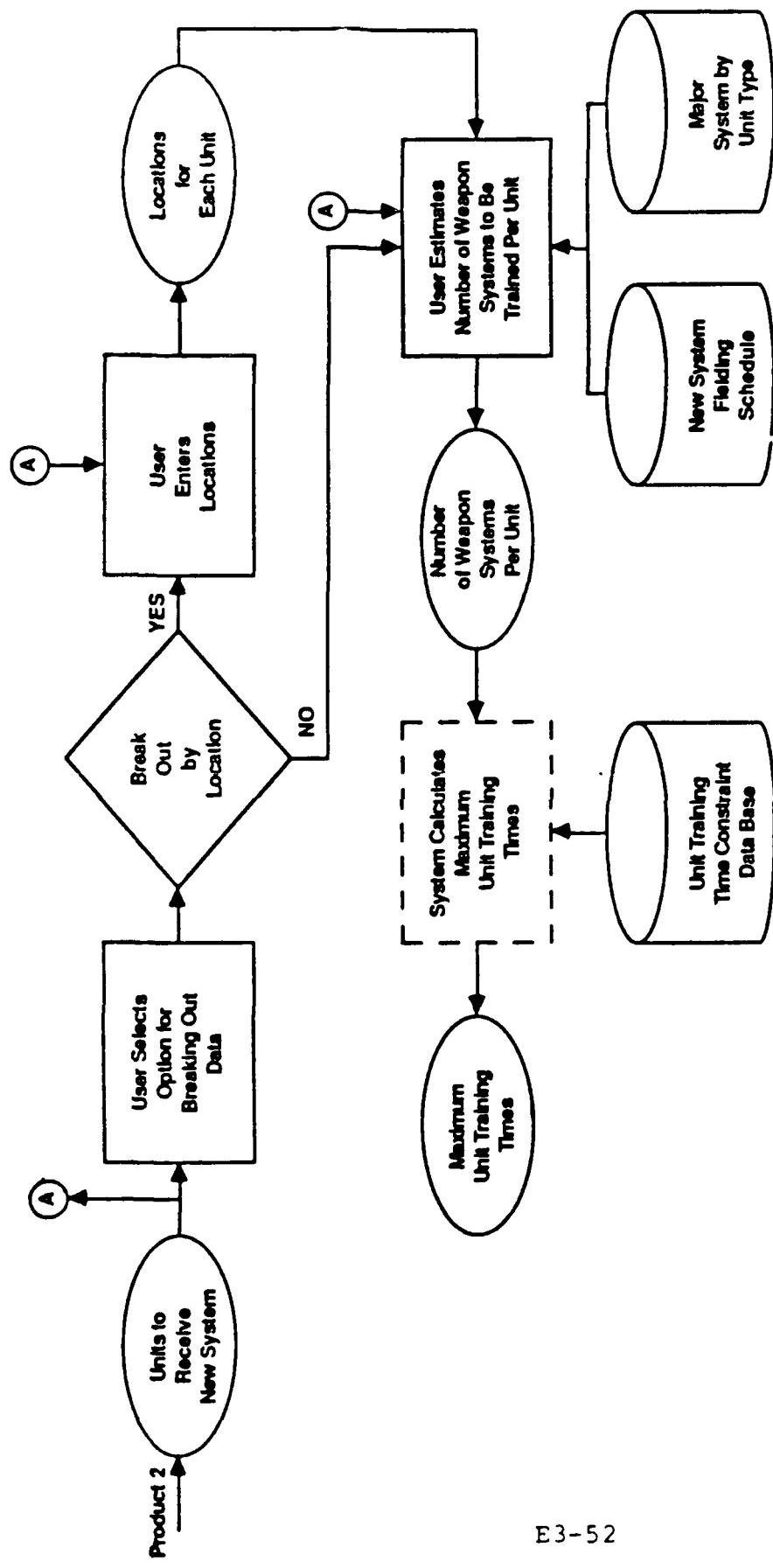


Figure 6. Overview of Logic for Estimating Maximum Unit Training Times.

devote to weapon system-specific training. The estimates will be broken out by mission area and by unit location.

Unfortunately, the information needed to complete the Unit Training Time Constraint Data Base is not available in any automated data base. To develop this information, we propose to send out a survey questionnaire to a representative sample of unit training managers. The survey will provide data for several of the TCEA steps. Table 7 lists the types of questions which will be included in the survey, and the TCEA steps which will use the survey data.

The survey will be developed in accordance with state-of-the-art guidelines for mail surveys (Altschuld & Lower, 1984; Dillman, 1978; Dyer, et al., 1976; Eudos, 1983; Sudman & Bradburn, 1982; Lockhart, 1984). DRC has successfully conducted a number of surveys for ARI. These surveys include studies on the Joint Optical Information Network (JOIN) (Lockhart, 1987), Analysis of the Soldier in Europe Survey Data (Lockhart, 1987), and the user survey for the Man Integrated System Technology (MIST) (Dynamics Research Corporation, 1985).

We will identify the type of units that operate and maintain major weapon systems and select a stratified sample of battalion unit training managers from each major command.

To obtain a high response rate, we will mail pre-notices, questionnaires, and follow-up items to the participants. In a recent DRC survey (Lockhart, et al., 1987) we used a series of five mailings to increase the number of respondents. This mailing schedule is outlined in Table 8.

The pre-notice informs the participants that the questionnaire is coming and asks them for their assistance. The survey is mailed out the week after the pre-notice. A reminder asks all participants to complete the survey and provides a toll-free number they can use for help. A second questionnaire is sent to soldiers who have not returned the first questionnaire within four weeks. A thank you letter is sent to each participant after receipt of a completed questionnaire.

Development of the Major System by Unit Data Base. The Major System by Unit Data Base will list the major systems associated with different unit types. A list of the major systems associated with a unit can be obtained from the TOE for that unit.

Table 7. Type of Questions to Be Included in Unit Training Time Survey.

| General Topic | Question Topics* | Use in TCEA | | | | | | | | | | |
|--|--|---|-------------|------------|---|------------|---|---|---|---|---|---|
| Background Information | <ul style="list-style-type: none"> - Unit Identification Code - Unit Location - Etc. | — | | | | | | | | | | |
| Maximum Annual Training Time | <p>Maximum time available per year for system-specific</p> <ul style="list-style-type: none"> - sustainment training - unit training | Used in the development of the Unit Training Time Constraint Data Base | | | | | | | | | | |
| Training Time Per Task | <p>The annual amount of time an individual in a specific unit typically spends in training the following individual and collective tasks:</p> <ul style="list-style-type: none"> — — — — | Used as criterion variable in regression analyses to develop unit training time prediction equations | | | | | | | | | | |
| Percentage Time Spent on Different Types of Training | <p>The percentage of system-specific training time using the following training types:</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <th>Type</th> <th>Percentages</th> </tr> <tr> <td>Individual</td> <td>—</td> </tr> <tr> <td>Collective</td> <td>—</td> </tr> <tr> <td>—</td> <td>—</td> </tr> <tr> <td>—</td> <td>—</td> </tr> </table> | Type | Percentages | Individual | — | Collective | — | — | — | — | — | Used in the development of the Training Type Allocation Guidelines |
| Type | Percentages | | | | | | | | | | | |
| Individual | — | | | | | | | | | | | |
| Collective | — | | | | | | | | | | | |
| — | — | | | | | | | | | | | |
| — | — | | | | | | | | | | | |

•These are not the actual questions that will be included in the survey. They are the topics that the questions will cover.

Table 8. Proposed Mailing Schedule for Unit Training Time Survey.

| <u>Mailing</u> | <u>Date</u> |
|-----------------------------|---------------------------------|
| Pre-notice | One Week Prior to Survey |
| Survey | |
| Reminder | One Week After Survey |
| Second Questionnaire | Four Weeks After Survey |
| Thank You | After Return of Survey |

Step 7: User Generates New System Generic Equipment List

Output

The output of this step will be (1) a generic equipment list for the new system, and (2) a list of the existing equipment most similar to the new system. By constructing the generic equipment list, users will be allocating operational functions to equipment types. This must be done before creating task statements for the new system. The list of similar equipment will help the user identify existing training factor ratings in the Training Factor Rating Data Base.

Input

External Input. The user will generate the generic equipment list and the list of similar equipment.

Internal Input. Product 1 will provide a list of the new system missions, functions, and performance requirements. Product 2 will provide a list of the systems to be replaced by the new system.

An on-line data base, called the Equipment by Major System Data Base, will also provide input to this step. This data base will list the major equipment items associated with Army weapon systems and the items included in the Training Factor Rating Data Base.

Process

Figure 7 provides an overview of the process for this step. The system will begin by constructing a list of the major equipment items of the systems being replaced. Product 2 will provide a list of the systems being replaced. The Equipment by Major System Data Base will list the major equipment items associated with existing Army weapon systems. The system will simply access this data base using the Product 2 replacement system list as a key.

In the second substep, the user will generate a generic equipment list for the new system. The user will (1) review the list of major equipment items associated with the replacement system, (2) add or delete items from this list to reflect the new system's mission, functions, and performance requirements, and (3) replace references to specific equipment with references to generic equipment (e.g., replace reference to T999 engine with reference to diesel engine). The user will also identify the replacement system equipment items associated with each generic equipment item.

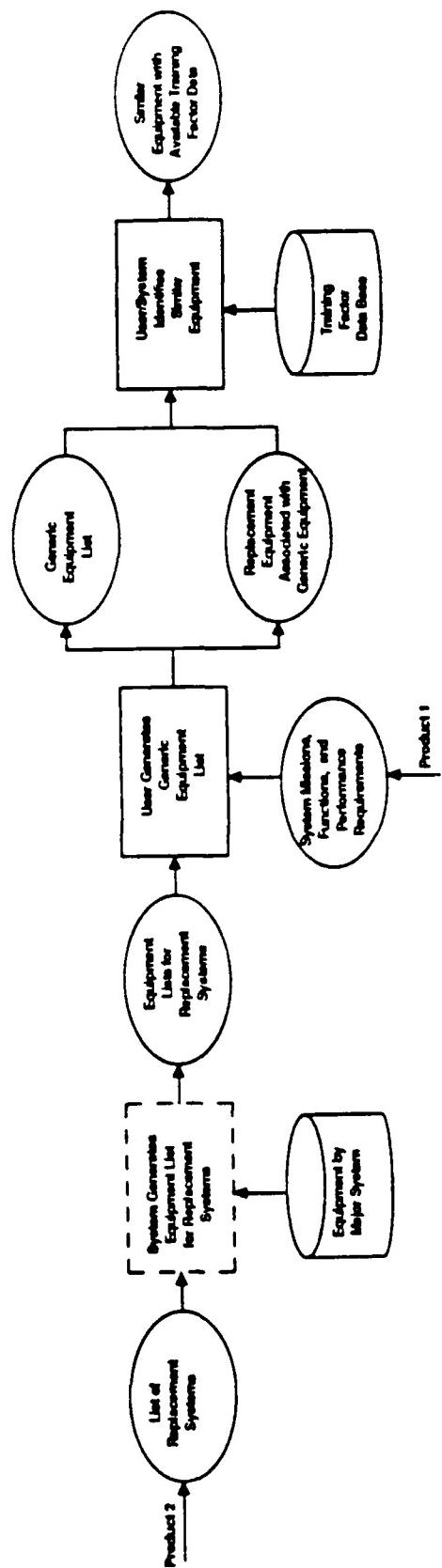


Figure 7. Overview of Logic for Generating Generic Equipment List.

In the third substep, the user will identify the existing equipment items which are expected to be most similar to the new system's generic equipment items in terms of time needed to train operators and maintainers and which have available training factor data. To assist the user, the system will identify the replacement items associated with the generic equipment items, and identify which of these replacement items have data in the Training Factor Rating Data Base. The user will also be able to query the Equipment by Major System Data Base to obtain a list of additional equipment. Each equipment item in the data base will be tied to the major system(s) in which it is embedded, and the major systems will be grouped by mission area.

MA&D/DRC Approach For Development

Development of the Equipment by Major System Data Base. This data base will list the major equipment items associated with the major weapon systems in each mission area. We expect about ten to fifteen major equipment items per weapon system. Lists of the major equipment items associated with a weapon system can be found in several sources including the AMIM and the MMMDDB. (DRC has on-line access to the AMMDB.)

Step 8: System Generates Maintenance Task List for New System

Output

This step will produce a maintenance task list for the new system. Product 1, the SPREA, will provide information on overall system performance requirements for both operations and maintenance. The SPREA will estimate the low-level operational functions associated with a system's mission. It is expected that these low-level operational functions can be mapped onto operator tasks on a one-to-one basis. However, we believe that Product 1 will not be able to produce an estimate of functions at the maintenance task level. It is difficult to identify maintenance tasks until operational functions have been allocated to particular types of equipment. The performance requirements for a maintenance task, indeed the maintenance tasks themselves, will depend on what it is that must be maintained. Product 1 must estimate functional performance requirements without any function allocation. Thus, in this context, it is unlikely that Product 1 can estimate maintenance tasks.

In the previous step, a preliminary function allocation was made to generic equipment items, and these generic items were linked to existing equipment items with established maintenance tasks. In this step, the system will access the AMMDB to obtain a listing of these maintenance tasks. The TCEA will generate a preliminary maintenance task list for the new system by

allocating maintenance tasks from the existing equipment to the new system generic equipment items.

Input

External Input. The user will be able to review and modify the new system maintenance task list.

The system will access the Army's fielded maintenance data collection system to generate a list of the maintenance tasks associated with the equipment items most similar to the new system.

Internal Input. Step 8 will provide a list of the existing equipment items which are most similar to the new system.

Process

The system will begin by obtaining a complete list of the maintenance tasks for existing equipment items which are most similar to the new system. The system will use a modem to call up the AMMDB. Then the system will enter and execute a data extraction program on the AMMDB host computer. The program will place the extracted data on a flat file and send it back to the user's computer. It may take the PREA an hour or more to make these data extractions. A message will appear on the screen estimating when they will be completed.

The system will create a preliminary list of maintenance tasks for the new system by constructing task statements that combine equipment items from the generic equipment list with task actions from similar existing equipment. The user will be able to review and modify these task statements.

MA&D/DRC Approach for Development

Development of Program for Extracting AMMDB Data. As part of Product 2, we will develop a program for extracting maintenance manhours information from the AMMDB. This program will extract total maintenance hours performed by a particular MOS and grade on a particular piece of equipment. The TCEA needs information one step below this level -- that is, it needs information on the individual maintenance tasks associated with these maintenance hours. This information is readily available in the AMMDB. We see no major technical difficulties associated

with modifying the Product 2 program to extract this additional data or constructing a new program should one not be created as part of Product 2. DRC already has on-line access to the AMMDB and has many programs for extracting data from this data base.

Step 9: User/System Generates Operator Task List

Output

This step will produce a complete set of operator task statements for the new system. Product 1 will produce a list of operational functions expected to be the same as operator task actions. However, to develop a complete task statement these task actions must be linked to equipment. Step 9 will make these linkages.

Input

External Input. The user will link the operational tasks from Product 1 to the generic equipment items identified in Step 1.

Internal Input. Product 1 will provide a list of the operational tasks expected to be associated with the new system. Product 2 will provide a list of the source MOSS for the new system. Step 1 will provide a list of the generic equipment items expected to be associated with the new system.

Process

The system will first present the user with a list of the operational tasks from Product 1 and ask the user to indicate which of these tasks will be performed by humans and if they will perform them. The system will then present the user with an operational task and a menu displaying generic equipment items. The user will indicate which items will be used to perform the operational task. The system will construct an operator task list by combining the operational tasks and the selected generic equipment items. The list will be presented to the user for review and update.

MA&D/DRC Approach for Development

We will create some simple software to combine task actions and equipment items into task statements.

Step 10: User Determines Training Factor Ratings for New System Tasks

Output

The system will produce a set of training factor ratings for each new system task. The system will identify similar existing tasks with existing training factor data. The user will review and modify these ratings to reflect the new system's performance requirements or expected equipment design.

Input

External Input. The system will automatically identify similar tasks. On some occasions, however, the user may have to assist the system in identifying the similar tasks.

Internal Input. Product 1 will provide a description of the new system's performance requirements. Step 7 will provide a list of the equipment items which are expected to be most similar to the new system equipment and the new system's generic equipment list. Step 8 will provide a complete maintenance task list for the new system. Step 9 will provide a complete operator task list for the new system.

Four on-line data bases will provide input to this step. Training factor ratings for the tasks associated with existing systems will be stored in the Training Factor Rating Data Base. The data base will contain the ratings from past analyses of these tasks. A Verb Thesaurus will identify synonyms for common task actions. A Task Taxonomy will group together action verbs based on similarities in training factor ratings. An Equipment Item Taxonomy will group together equipment items based on similarities in the training factor ratings for their associated tasks.

Process

Figure 8 provides an overview of the process for this step. The user can either use training factor ratings from similar existing tasks to guide his or her ratings, or enter the training factor ratings for the new system directly without using baseline information from similar tasks. If the user decides to use the baseline information, the system will begin by selecting a task from the new system operator or maintainer task list. The system will identify the similar equipment associated with this task in Step 1. It will then examine the task actions in the

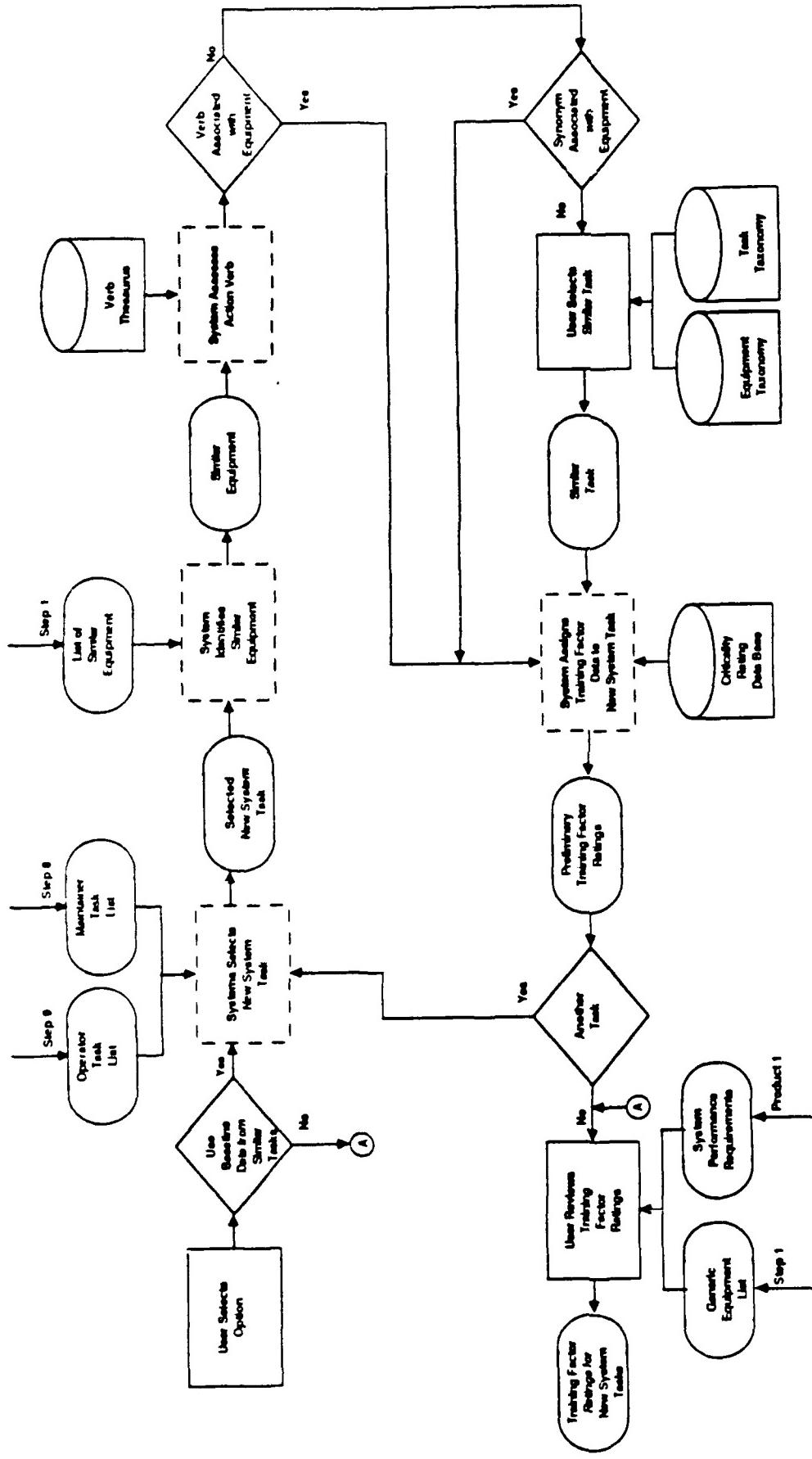


Figure 8. Overview of Logic for Identifying Training Factor Ratings from Similar Systems.

Training Factor Rating Data Base associated with this equipment and compare them to the new system task action verb. If one of these actions matches the verb, the system will extract the training factor ratings for the task and temporarily assign them to the new system task. If there is not a match, the system will use the Verb Thesaurus to find a synonym. If there is no synonym, the user will be asked to pick a similar task from the Training Factor Rating Data Base. The user will be able to examine the Equipment Taxonomy and the Task Taxonomy.

The user can review the training factor ratings associated with the similar tasks and update them to reflect the new system's equipment design and system performance requirements.

MA&D/DRC Approach For Development

Data for Training Factor Data Base. All of the data in the Training Factor Rating Data Base will be obtained from the CODAP data base, which is part of the Army Occupational Survey Program (AOOSP). We will request a tape extract containing results from all of the training factor surveys conducted by AOOSP since 1981, the year when the surveys were initiated. We will load into the TCEA Training Factor data base only those factors which are part of our training time prediction model (that is, those factors which are significant predictors of institutional or unit training time). See the section entitled "MA&D/DRC Approach for Development," pp. 64-66 for a detailed description of our approach to developing this model.

Our approach does not require that the Training Factor Data Base contain task factor ratings for all Army tasks. All that we need are ratings for a fairly large number of tasks. The purpose of the Training Factor Data Base is to provide the user with some baseline data from a similar task. If data are not there for one particular task, the user can identify another task that does have existing data.

Development of Task Verb Thesaurus. There are several microcomputer-based data base management systems which already have front-end natural language processors. If we use one of these data bases to store the Training Factor Rating Data Base, we should be able to use its processor to identify verb synonyms. If we don't use one of these data bases, a simple thesaurus of approximately 100 verbs can be created.

Development of Task Taxonomy. The task taxonomy will group together task actions based on similarities in their training factor ratings. To create this taxonomy, mean scores on each training factor measure will be created for each task action by averaging across all tasks which use that action in the data base. Profile difference scores between the actions on the mean

training factor ratings will then be created. These profile difference scores will provide a measure of the similarity of one action to another. The profile differences scores will be entered into a cluster analysis routine which will produce the task action clusters which will form the taxonomy.

Table 9 summarizes some of the different clustering techniques that could be used in this analysis. We will select one of these techniques during development of the detailed design specifications.

Development of Equipment Taxonomy. The equipment taxonomy will group together equipment items based on similarities in the equipment items. To create this taxonomy, mean scores on each training factor measure will be created for each equipment by averaging across all the tasks associated with that equipment item in the data base. Profile difference scores between the equipment items on the mean training factor ratings will then be created. These profile difference scores will provide a measure of the similarity of one equipment item to another. The profile differences scores will be entered into a cluster analysis routine which will produce the equipment item groups which will form the taxonomy.

Step 11: System Estimates Likely Training Time

Output

The output of this step will be an estimate of the time to train each new system task. Separate estimates will be provided for initial institutional training (i.e., AIT) and for unit training.

Input

External Input. None. This step will be completely automated.

Internal Input. Step 10 will provide a set of task criticality ratings for each task.

Process

A Training Time Production Model will contain a set of regression equations which will predict training time as a function of the training factor ratings. Separate equations will predict initial institutional and unit training time. The initial training time equation will estimate the time which is

Table 9. Potential Clustering Techniques.

| TECHNIQUE | CLASSIFICATION | SELECTION CRITERION | COMPUTATIONAL COMPLEXITY | COMMENTS |
|--|--|---|--|---|
| Single Linkage | Hierarchical — Linkage | Merge cluster A and cluster B for which $S_{AB} = \min \{S_{ij} i \in A, j \in B\}$ is the smallest. | low | <ul style="list-style-type: none"> • excellent intuitive clarity |
| Complete Linkage | Hierarchical — Linkage | Merge cluster A and cluster B for which $S_{AB} = \max \{S_{ij} i \in A, j \in B\}$ is the smallest. | low | <ul style="list-style-type: none"> • excellent intuitive clarity |
| Centroid | Hierarchical | Merge cluster A and cluster B for which $S_{AB} = \left\{ \begin{array}{l} \text{distance between the} \\ \text{centroid of A and} \\ \text{centroid of B} \end{array} \right\}$ is the smallest. | moderate | <ul style="list-style-type: none"> • automated • excellent intuitive clarity |
| The Ward Criterion | Hierarchical — Error Sum of Squares | Merge the clusters so that total within group error sum of squares is minimized. | high | <ul style="list-style-type: none"> • automated • heavily influenced by group size • moderate intuitive clarity |
| Minimum Total Within Group Sum of Squares in the New Cluster | Hierarchical — Error Sum of Squares | Merge the clusters so that the within-group error sum of squares in the <u>new</u> cluster is minimized. | high (slightly less than the Ward Criterion) | <ul style="list-style-type: none"> • automated • heavily influenced by group size • moderate intuitive clarity |
| Minimum Average Within Group Sum of Squares in the New Cluster | Hierarchical — Error Sum of Squares | Merge the clusters so that the average within-group error sum of squares in the <u>new</u> cluster is minimized. | high | <ul style="list-style-type: none"> • automated • heavily influenced by group size • moderate intuitive clarity |
| Forgy's Algorithm | Non-hierarchical — Seed points | Assign each task to the seed task to which it is most similar. Cluster centroids become new seed points. Iterates. | moderate to high | <ul style="list-style-type: none"> • moderate intuitive clarity |
| Jeney's Algorithm | Non-hierarchical — Seed points | Assign each task to the seed task to which it is most similar. New seed points are reflection of old seed points through centroids. Iterates. | high | <ul style="list-style-type: none"> • intuitively hard to grasp |
| MacQueen's K-means algorithm | Non-hierarchical — Seed points | Assign <u>one</u> task to the seed to which it is most similar. Cluster centroids become new seed points. Iterates. | moderate to high | <ul style="list-style-type: none"> • moderate intuitive clarity |
| Jorgenson's TEEM Algorithm | Non-hierarchical — Error Sum of Squares | Merge cluster A and B for which a linear combination of total between group error sum of squares minus total between group error sum of squares is maximized. | high | <ul style="list-style-type: none"> • automated • heavily influenced by number of groups • moderate intuitive clarity |
| Post-Cluster Allocation Algorithms | Dependent on clustering technique initially used | After some form of clustering has been performed, assign each task to all clusters for which it meets or exceeds the appropriate similarity measure set by other cluster members. | dependent of clustering technique initially used | <ul style="list-style-type: none"> • automated versions available • technique to include tasks in more than 1 cluster • moderate intuitive clarity |
| Linkage-based network algorithms | Non-hierarchical — Linkage | Link together tasks for which the intertask distance is less than or equal to some maximum, D. | moderate | <ul style="list-style-type: none"> • excellent intuitive clarity • allows task to be assigned to more than one cluster |

likely to be spent training the task during the initial institutional training. The unit training equation will estimate the annual time spent training a task in a unit. Each mission area will have a separate set of prediction equations.

MA&D/DRC Approach for Development

To develop the training time prediction equations, we will conduct a series of regression analyses using the training factors as predictors and the time to train a task as a criterion. We will develop equations to predict institutional and unit training time within each mission area.

To develop the data for the regression analysis, we will select a sample of tasks for each mission area from the CODAP data base. We will extract data on the nine training factors from this data base. Table 10 describes the scales used to obtain ratings for each of the factors. The average percent time performing ratings are completed by enlisted personnel as part of their basic survey. As part of this survey, these personnel indicate which tasks they perform. The percent members performing score is derived from an analysis of this data. Ratings on the seven other training factors are provided by senior NCOs in a supplementary survey.

We will obtain data on the time spent in training the tasks in initial training by examining the Program of Instruction for the initial institutional training course. (This course can be identified by examining the Trainer's Guide for the MOS associated with the task.)

We will obtain estimates of the annual amount of time spent in unit training from a survey questionnaire sent to unit training managers. We will use this same survey to determine the maximum time available to train all system tasks. See the section entitled "Step 6: System Estimates Maximum Unit Training Times", p. 51 for a more detailed description of the survey procedures.

Once we have collected data on training time, we will conduct a series of step-wise regression analyses using the training factor variables as predictors and the unit and institutional training time measures as criterion variables. In conducting the regression analyses, we will identify the minimum number of training factor variables needed to predict training time for each mission area. By minimizing the number of training factor variables, we can reduce the number of ratings that users must provide in Step 10. Several studies indicate that the nine training factors are redundant and can be reduced to a smaller number.

Table 10. Training Factor Rating Scales.

| Training Factor | Definition | Scale | Source of Rating |
|---|--|--|----------------------------|
| Percent of members performing | Percent of job incumbents who perform the task | Percent scale based upon proportion of Yes/No responses | Self-Report (Enlisted) |
| Average percent of time spent by members performing | Average percent time spent on the task relative to time spent on all other tasks | 7 - Point Relevant Time Spent scale (1 - Very much below average to 7 - Very much above average) | Self-Report (Enlisted) |
| Task Learning Difficulty | The amount of time required to learn to perform the task satisfactorily | 7 - Point scale (1 - Extremely low learning difficulty to 7 - Extremely high learning difficulty) | Supervisory Ratings (NCOs) |
| Consequences of Inadequate Performance | The consequences of performing the task inadequately upon personnel injury, loss of life, equipment damage | 7 - Point scale (1 - Extremely low consequence to 7 - Extremely high consequence) | Supervisory Ratings (NCOs) |
| Task Delay Tolerance | The amount of delay that can be tolerated between the time the need for task performance becomes evident and the time that actual performance begins | 7 - Point scale (1 - Extremely low [urgency] to 7 - Extremely high [urgency]) | Supervisory Ratings (NCOs) |
| Probability of Deficient Performance | The likelihood that the task will be performed poorly | 7 - Point scale (1 - Never performed deficiently to 7 - Very frequently performed deficiently) | Supervisory Ratings (NCOs) |
| Immediacy of Performance | The time between the task training and the first task performance on the job | 7 - Point scale (1 - Never performed to 7 - Initially performed less than 3 months after individual training) | Supervisory Ratings (NCOs) |
| Relative Frequency | The frequency of performing the task | 7 - Point scale (1 - Very seldom to 7 - Very frequently) | Supervisory Ratings (NCOs) |
| Training Emphasis | The emphasis that should be given to the task during systematic training (e.g., Formal school training, On-the-Job training, etc.) | 7 - Point scale (1 - Very low emphasis to 7 - Very high emphasis) | Supervisory Ratings (NCOs) |

A recent study by Goldman (1985) examined the reliability of the nine training factors in six MOSs. The study calculated the average inter-rater reliability of a single rater (r_{11}) and the stepped-up reliability coefficients reflecting the overall group of raters for a particular training factor (r_{kk}). In general, the study found that the r_{11} values were moderate while the r_{kk} values were consistently high across all MOSs.

Goldman also examined the interrelationships among the training factors and found statistically significant correlations across all MOSs. It was therefore not surprising that only two factors emerged from a factor analysis of the training factor data in each of the six MOSs.

Goldman also examined the success of the seven NCO-rated training factors in predicting what tasks were actually trained; that is, which AOSP tasks were designated critical and hence included in the Soldier's Manual. Goldman conducted a stepwise discriminant analysis to determine the fewest number of training factors needed to successfully identify the critical tasks. Goldman found that only two factors, training emphasis and consequences of inadequate performance, were needed to predict what tasks were designated critical. These results parallel results from a previous Air Force occupational survey study by Ruck, Thompson, Brown, & Stacey (1978).

The results of Goldman & Ruck, et al. are encouraging. They suggest that only a small number of the training factors may be needed to predict training time, at least for institutional training. A small number of factors would reduce the size of the TCEA data bases, and reduce user input requirements.

Step 12: System Allocates Training Time Among Types

Output

The output of this step will be the amount of time spent in training a task with different "types" of training.

In initial institutional training, training type will refer to different types of methods and media. To describe training methods we will use the taxonomy of training methods used by TRADOC in its POIs (see Table 11). To describe training media, we will use the taxonomy displayed in Table 12. Note that this taxonomy primarily distinguishes between different types of training devices. We propose this approach because training devices are the media which are most costly and have had the biggest demonstrated impact on training task performance.

Table 11. Types of Instruction and Associated Instructor-to-Student Ratios.

| <u>SYMBOL</u> | <u>TYPE OF INSTRUCTION</u> | <u>I/S RATIO</u> |
|---------------|--|------------------|
| C | Conference (or Lecture) | 1:Class |
| CAI | Computer-Assisted Instruction | 1:20 |
| CS | Case Study | 1:20 |
| D | Demonstration | 1:20 |
| DF/SF | <ul style="list-style-type: none"> • Dual or Solo Flight (Aviator Courses Only) • Hardware Performance Examination • Nonhardware Performance Examination • Written Examination | - |
| E1 | Electives | 1:6 |
| E2 | Film | 1:6 |
| E3 | Guest Speaker | 1:Class |
| EL | Practical Exercise: | 1:6 |
| F | Hardware Oriented | 1:Class |
| GS | Practical Exercise: | 1:Class |
| PE1 | Nonhardware Oriented | 1:6 |
| PE2 | Practical Exercise: | 1:6 |
| PE3 | Practical Exercise: | 1:6 |
| P1 | Classroom | 1:20 |
| S | Programmed Instruction (Using Programmed Text) | 1:20 |
| TV | Seminar | 1:Class |
| | Television | |

* Typically not included in ICH computations

Self-paced (SP) and group-paced (GO) are indicated after the type of instruction symbol, e.g., CAI-SP

NOTE: TRADOC schools are not limited to the above types of instruction. An explanation for any type of instruction not specified in the regulation should be found in the course summary.

SOURCE: TRADOC Reg 351-1, Training Requirements Analysis System (TRAS)

Table 12. Example of Media Types*

| |
|--|
| <u>Armor</u> |
| Conduct-of-Fire Trainers |
| Tank Trainers (Driving/Gunnery/Turret) |
| Tracked Vehicle Driving Trainer |
| <u>Weapons & Ordnance</u> |
| Firing Simulator Systems |
| <u>Signal</u> |
| Countermeasures Training Signal Transmitting Set |
| Digital Computer Trainer |
| <u>Aviation</u> |
| Flight Simulator |
| Composite Trainer |
| Armament Systems Trainer |
| Hydraulic & Electrical Systems Trainer |
| Flight Control System Trainer |
| Panel Trainers |
| Instrument & Display Trainers |
| Radar Operator & Target Simulator |
| Power Plant/Drive System Trainers |
| Ejection Seat Trainer |
| Cockpit Procedures Trainers |
| <u>Air Defense Artillery</u> |
| Armament Maintenance Trainer |
| Guided Missile Intercept - Aerial Trainer |
| Guided Missile System Radar Signal Simulator |
| <u>Field Artillery</u> |
| Field Artillery Trainer: |
| Programmer - Test Station |
| <u>Operational Equipment</u> |

*Derived from DA PAM 310-12 Index and Description of Army Training Devices

In unit training, training type will refer to (a) training level, either individual or collective, and (b) type of training media. The same media categories used for institutional training will be used for unit training.

Input

External Input. None. This step will be completely automated.

Internal Input. Step 11 will provide estimates of the total initial institutional and unit training time.

An on-line data base called the Training Type Allocation Guidelines will estimate the percentage of time spent on each type of training in a mission area. Separate guidelines will cover institutional and unit training.

Process

The system will apply the percentages from the Training Type Allocation Guidelines to the total training time estimates from Step 11 to produce estimates of the time spent on each institutional and unit training type.

MA&D/DRC Approach for Development

Development of Training Type Allocation Guidelines. We will develop the Training Type Allocation Guidelines in a two-stage process. In the first stage, we will identify the percentage of time spent on each training type. For institutional training, MA&D/DRC personnel will extract this information from a representative set of POIs for each mission area. The POIs typically have sections summarizing the amount of time spent with different methods and different types of major media such as training devices. We will simply extract the necessary information from the POI and average them.

For unit training, we will obtain information on the time spent on different types of training through the unit training survey described in Steps 6 and 11 (see p. 51). A section of this survey will ask unit training managers to estimate the percentage of time currently spent on different types of training.

In the second stage, we will estimate the percentage of time that each training type is expected to be used in training each task in the future (i.e., the 1988-1995 time frame). We will

present the current percentages described above to individuals from the Army Training Board and Training Technology Agency and ask them to modify them to reflect expected future trends in Army training technology. These agencies play a critical role in shaping long-term training trends within the Army.

The Army Training Board's mission is to:

- Establish and maintain links with the TRADOC integrating center, service schools, training activities, and active and reserve component units.
- Foster communication and exchange of information pertaining to development and use of service school training materials and initiatives.
- Collect, evaluate, and disseminate information on successful new training methods, management practices, and materials.
- Sponsor research, studies, and tests to improve training development and conduct.
- Provide feedback to TRADOC for the development of improved training materials and techniques.
- Provide feedback to TRADOC and other Army activities in the education and training of senior managers associated with training and doctrine development.

The Training Technology Agency's role is to facilitate the transfer of new training technologies to Army training proponents.

Step 13: System Compares Likely Training Time with Maximum Training Time

Output

During this step, the system will compare estimated training time to the maximum training time constraint and identify shortfalls (that is, cases where the estimated training time exceeds the maximum available training time). Separate estimates will be made for initial institutional and unit training.

Input

External Input. None. The user will receive a report describing any shortfalls that are identified.

Internal Input. Step 5 will provide estimates of maximum training time for initial training. Step 6 will provide estimates of maximum training time for unit training. Step 11 will provide an estimate of the likely institutional and unit training times for each task.

Process

The system will obtain the likely training time estimates for each task generated by Step 11 and aggregate them to produce estimates of total likely training time for each MOS. The system will develop separate estimates for institutional and unit training. The institutional training estimate will be compared with the maximum time constraint identified by Step 5. The unit training estimate will be compared with the maximum training time constraint identified by Step 6. A report will be generated listing any MOSs which have shortfalls, the size of the shortfall, and the associated maximum and likely training time estimates.

MA&D/DRC Approach for Development

We will develop a simple program to generate the report describing training time shortfalls.

Step 14: System/User Iterate Steps Until Shortfalls Eliminated

Output

During this step, the user can change key parameters and iterate the TCEA steps until training time shortfalls have been eliminated.

Input

External Input. The user must identify which of the key TCEA input parameters he or she would like to modify and input new values for these parameters.

Process

The system will present the user with a menu containing a prioritized list of the input parameters that can be changed to eliminate a training time shortfall. The user will select which of these parameters will be modified. The TCEA will then guide

The user through the steps to enter new values for these parameters and calculate the impact on training time shortfalls. Table 13 lists the key parameters which can be modified, the steps where the modifications are made, and the steps which must be iterated to calculate the impact on training time shortfalls. The system will prompt the user to provide a description of the rationale underlying any changes to the key input parameters.

MA&D/DRC Approach for Development

We will create software to provide the branching from step-to-step that will be associated with TCEA iteration. We will create additional software to help the TCEA keep track of parameter values associated with any particular iteration or set of iterations.

Table 13. Recommended Sequence for Modifying TCEA Parameters.

| Priority | Parameter | Step(s) In Which Parameter Is Modified | Subsequent Steps That Must Be Iterated |
|----------|--|--|--|
| 1 | New System Manpower Requirements | Step 4 | Steps 5, 6, 13, and 14 |
| 2 | New System Task Lists | Steps 8 and 9 | Steps 10, 11, 13, and 14 |
| 3 | New System Training Factor Ratings | Step 10 | Steps 11, 13, and 14 |
| 4 | Source MOS and Associated Institutional Course | Step 1 | Steps 2, 3, 4, 5, 13, and 14 |
| 5 | Institutional Course Length | Step 1 | Steps 2, 3, 5, 13, and 14 |
| 6 | Institutional Course Trainee Input Capacity | Step 1 | Steps 2, 3, 5, 13, and 14 |
| 7 | Portion of Institutional Course Devoted to Other Systems | Step 2 | Steps 3, 5, 13, and 14 |
| 8 | MOS Attrition/Promotion Rates | Step 4 | Steps 5, 6, 13, and 14 |
| 9 | Unit Training Time Constraint Factors | Step 6 | Steps 13 and 14 |

DESCRIPTION AND DEVELOPMENT OF AUTOMATED COMPONENTS

We must develop four different types of software to support the TCEA:

- Input/Output frames that provide mechanisms for users to select options or commands, input data, or generate output reports.
- Models that describe quantitative algorithms for transforming the data.
- Permanent data base libraries for critical data.
- Temporary files that store data associated with a particular user's TCEA application.

Details on the specific TCEA data bases and models appear below.

An Applications Manager will control all of the software components.

We are purposely repeating material in Sections 4 and 5. We hope doing so will make it easier to read each section independently.

Data Base Libraries

Table 14 lists the data base libraries that must be developed for each step of the TCEA. The section which follows describes the data sources and procedures we will use to develop each of these libraries.

Development of New System Fielding Schedule. The New System Fielding Schedule will describe the major new weapon systems which are expected to be fielded in each mission area, the systems they will replace, and the date they are expected to be fielded. All of the information needed to produce the New System Fielding Schedule is available in the AMIM. We will simply review these data and place them in the data base.

Development of the Unit Training Time Constraint Data Base. The Unit Training Time Constraint data base will list the maximum amount of time that different types of units are expected to have to devote to weapon system-specific training. The estimates will be broken out by mission area and by unit location.

Unfortunately, the information needed to complete the Unit Training Time Constraint data base is not available in any automated data base. To develop this information, we propose to

Table 14. List of Data Bases in the TCEA.

New System Fielding Schedule

Unit Training Time Constraint Data Base

Major System by Unit Data Base

Equipment by Major System Data Base

Training Factor Data Base

Task Verb Thesaurus

Task Taxonomy

Equipment Taxonomy

Training Type Allocation Guidelines

send out a survey questionnaire to a representative sample of unit training managers. The survey will provide data for several of the TCEA steps. Table 15 lists the type of questions that will be included in the survey and the relevant TCEA steps.

We will develop the survey in accordance with state-of-the-art guidelines for mail surveys (Altschuld & Lower, 1984; Dillman, 1978; Dyer, et al., 1976; Eudos, 1983; Sudman & Bradburn, 1982; Lockhart, 1984). DRC has successfully conducted a number of surveys for ARI. These surveys include studies on the Joint Optical Information Network (JOIN) (Lockhart et al., 1987), Analysis of the Soldier In Europe Survey Data (Lockhart, 1987), and the user survey for the Man Integrated Systems Technology (MIST) (Dynamics Research Corporation, 1985).

We will identify the type of units that operate or maintain major weapon systems and select a stratified sample of battalion unit training managers from each major command.

To obtain a high response rate, we will mail pre-notices, questionnaires, and follow-up items to the participants. In a recent DRC survey (Lockhart, et al., 1987), we used a series of five mailings to increase the number of respondents. Table 16 outlines this mailing schedule.

The pre-notice informs the participants that the questionnaire is coming and asks them for their assistance. The survey is mailed out the week after the pre-notice. A reminder asks all participants to complete the survey and provides a toll-free number they can use for help. The second questionnaire is sent to soldiers who have not returned the first questionnaire within four weeks. A thank you letter is sent to each participant after receipt of a completed questionnaire.

Development of the Major System by Unit Data Base. The Major System by Unit Data Base will list the major systems associated with different unit types. A list of the major systems associated with each unit type can be obtained from the TOE associated with that unit.

Development of the Equipment by Major System Data Base. This data base will list the major equipment items associated with major weapon systems in each mission area. We expect about 10 to 15 of these items per weapon system. Lists of the major equipment items associated with a weapon system can be found in several sources including the AMIM and the AMMDB. (DRC has on-line access to the AMMDB).

Table 15. Type of Questions to Be Included in Unit Training Time Survey.

| General Topic | Question Topics* | Use In TCEA | | | | | | | | | | | | | | | | |
|--|---|---|-------------|------------|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| Background Information | <ul style="list-style-type: none"> - Unit Identification Code - Unit Location - Etc. | _____ | | | | | | | | | | | | | | | | |
| Maximum Annual Training Time | Maximum time available per year for system-specific <ul style="list-style-type: none"> - sustainment training - unit training | Used in the development of the Unit Training Time Constraint Data Base | | | | | | | | | | | | | | | | |
| Training Time Per Task | <p>The annual amount of time an individual in a specific unit typically spends in training the following individual and collective tasks:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> | <p>Used as criterion variable in regression analyses to develop unit training time prediction equations</p> <p>_____</p> <p>_____</p> <p>_____</p> | | | | | | | | | | | | | | | | |
| Percentage Time Spent on Different Types of Training | <p>The percentage of system-specific training time using the following training types:</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Type</th> <th style="text-align: center;">Individual</th> <th style="text-align: center;">Collective</th> <th style="text-align: center;">Percentages</th> </tr> </thead> <tbody> <tr> <td>_____</td> <td>_____</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>_____</td> <td>_____</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>_____</td> <td>_____</td> <td>_____</td> <td>_____</td> </tr> </tbody> </table> | Type | Individual | Collective | Percentages | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ | <p>Used in the development of the Training Type Allocation Guidelines</p> <p>_____</p> <p>_____</p> <p>_____</p> |
| Type | Individual | Collective | Percentages | | | | | | | | | | | | | | | |
| _____ | _____ | _____ | _____ | | | | | | | | | | | | | | | |
| _____ | _____ | _____ | _____ | | | | | | | | | | | | | | | |
| _____ | _____ | _____ | _____ | | | | | | | | | | | | | | | |

*These are not the actual questions that will be included in the survey. They are the topics that the questions will cover.

Table 16. Proposed Mailing Schedule for Unit Training Time Survey.

| <u>Mailing</u> | <u>Date</u> |
|-----------------------|--------------------------|
| Pre-notice | One Week Prior to Survey |
| Survey | |
| Reminder | One Week After Survey |
| Second Questionnaire | Four Weeks After Survey |
| Thank You | After Return of Survey |

Data for Training Factor Data Base. We will obtain all of the data in the Training Factor Rating Data Base from the CODAP data base, which is part of the Army Occupational Survey Program (AOSP). Table 17 describes the nine training factors in the CODAP data base. During the development of the TCEA, we will request a tape extract that contains results from all of the training factor surveys conducted by AOSP since 1981, the year when these surveys were initiated. We will load into the TCEA Training Factor Data Base only those factors which are part of our training time prediction model; that is, those factors that are significant predictors of institutional or unit training time. See the section entitled "MA&D/DRC Approach for Development," pp. 64-66 for detailed description of our approach to developing this model.

Our approach does not require that the Training Factor Data Base contain task factor ratings for all Army tasks. All that we need are ratings for a fairly large number of tasks. The purpose of the Training Factor Data Base is to provide the user with some baseline data from a similar task. If data are not there for one particular task, the user can identify another similar task which does have existing data.

Development of Task Verb Thesaurus. There are several microcomputer-based data base management systems which already have front-end natural language processors. If we use one of these data bases to store the Task Factor Ratings Data Base, we should be able to use its processor to identify verb synonyms. If we don't use one of these data bases, we can create a simple thesaurus of approximately 100 verbs.

Development of Task Taxonomy. The task taxonomy will group together task actions based on similarities in their training factor ratings. To create this taxonomy, mean scores on each training factor measure will be created for each task action by averaging across all task which use that action in the data base. Profile difference scores will provide a measure of the similarity of one action to another. The profile difference scores will be entered into a cluster analysis routine, which will produce the task action clusters to form the taxonomy. Table 18 summarizes some of the different clustering techniques that could be used in this analysis. We will select one of these techniques during development of the detailed design specifications.

Development of Equipment Taxonomy. The equipment taxonomy will group together equipment items based on similarities in the training factor ratings of the tasks associated with these equipment items. To create this taxonomy, mean scores on each

Table 17. Training Factor Rating Scales.

| Training Factor | Definition | Scale | Source of Rating |
|---|--|--|----------------------------|
| Percent of members performing | Percent of job incumbents who perform the task | Percent scale based upon proportion of Yes/No responses | Self-Report (Enlisted) |
| Average percent of time spent by members performing | Average percent time spent on the task relative to time spent on all other tasks | 7 - Point Relevant Time Spent scale (1 - Very much below average to 7 - Very much above average) | Self-Report (Enlisted) |
| Task Learning Difficulty | The amount of time required to learn to perform the task satisfactorily | 7 - Point scale (1 - Extremely low learning difficulty to 7 - Extremely high learning difficulty) | Supervisory Ratings (NCOs) |
| Consequences of Inadequate Performance | The consequences of performing the task inadequately upon personnel injury, loss of life, equipment damage | 7 - Point scale (1 - Extremely low consequence to 7 - Extremely high consequence) | Supervisory Ratings (NCOs) |
| Task Delay Tolerance | The amount of delay that can be tolerated between the time the need for task performance becomes evident and the time that actual performance begins | 7 - Point scale (1 - Extremely low [urgency] to 7 - Extremely high [urgency]) | Supervisory Ratings (NCOs) |
| Probability of Deficient Performance | The likelihood that the task will be performed poorly | 7 - Point scale (1 - Never performed deficiently to 7 - Very frequently performed deficiently) | Supervisory Ratings (NCOs) |
| Immediacy of Performance | The time between the task training and the first task performance on the job | 7 - Point scale (1 - Never performed to 7 - Initially performed less than 3 months after individual training) | Supervisory Ratings (NCOs) |
| Relative Frequency | The frequency of performing the task | 7 - Point scale (1 - Very seldom to 7 - Very frequently) | Supervisory Ratings (NCOs) |
| Training Emphasis | The emphasis that should be given to the task during systematic training (e.g., Formal school training, On-the-Job training, etc.) | 7 - Point scale (1 - Very low emphasis to 7 - Very high emphasis) | Supervisory Ratings (NCOs) |

Table 18. Potential Clustering Techniques.

| TECHNIQUE | CLASSIFICATION | SELECTION CRITERION | COMPUTATIONAL COMPLEXITY | COMMENTS |
|--|--|---|--|---|
| Single Linkage | Hierarchical – Linkage | Merge cluster A and cluster B for which $S_{AB} = \min \{S_{ij} i \in A, j \in B\}$ is the smallest. | low | <ul style="list-style-type: none"> • excellent intuitive clarity |
| Complete Linkage | Hierarchical – Linkage | Merge cluster A and cluster B for which $S_{AB} = \max \{S_{ij} i \in A, j \in B\}$ is the smallest. | low | <ul style="list-style-type: none"> • excellent intuitive clarity |
| Centroid | Hierarchical | Merge cluster A and cluster B for which (distance between the $S_{AB} = \sqrt{\frac{\sum_{i \in A} \sum_{j \in B} (x_{ij} - \bar{x}_A - \bar{x}_B)^2}{ A B }}$ is the smallest. | moderate | <ul style="list-style-type: none"> • automated • excellent intuitive clarity |
| The Ward Criterion | Hierarchical – Error Sum of Squares | Merge the clusters so that total within group error sum of squares is minimized. | high | <ul style="list-style-type: none"> • automated • heavily influenced by group size • moderate intuitive clarity |
| Minimum Total Within Group Sum of Squares in the New Cluster | Hierarchical – Error Sum of Squares | Merge the clusters so that the within-group error sum of squares in the <u>new</u> cluster is minimized. | high (slightly less than the Ward Criterion) | <ul style="list-style-type: none"> • automated • heavily influenced by group size • moderate intuitive clarity |
| Minimum Average Within Group Sum of Squares in the New Cluster | Hierarchical – Error Sum of Squares | Merge the clusters so that the <u>average</u> within-group error sum of squares in the <u>new</u> cluster is minimized. | high | <ul style="list-style-type: none"> • automated • heavily influenced by group size • moderate intuitive clarity |
| Forgy's Algorithm | Non-hierarchical – Seed points | Assign each task to the seed task to which it is most similar. Cluster centroids become new seed points. Iterate. | moderate to high | <ul style="list-style-type: none"> • moderate intuitive clarity |
| Jancev's Algorithm | Non-hierarchical – Seed points | Assign each task to the seed task to which it is most similar. New seed points are reflection of old seed points through centroids. Iterate. | high | <ul style="list-style-type: none"> • intuitively hard to grasp |
| MacQueen's K-means algorithm | Non-hierarchical – Seed points | Assign <u>one</u> task to the seed to which it is most similar. Cluster centroids become new seed points. Iterate. | moderate to high | <ul style="list-style-type: none"> • moderate intuitive clarity |
| Jorgensen's TEEM Algorithm | Non-hierarchical – Error Sum of Squares | Merge cluster A and B for which a linear combination of total between group error sum of squares minus total between group error sum of squares is maximized. | high | <ul style="list-style-type: none"> • automated • heavily influenced by number of groups • moderate intuitive clarity |
| Post-Cluster Allocation Algorithms | Dependent on clustering technique initially used | After some form of clustering has been performed, assign each task to all clusters for which it meets or exceeds the appropriate similarity measure met by other cluster members. | dependent of clustering technique initially used | <ul style="list-style-type: none"> • automated versions available • technique to include tasks in more than 1 cluster • moderate intuitive clarity |
| Linkage-based network algorithms | Non-hierarchical – Linkage | Link together tasks for which the intertask distance is less than or equal to some maximum, D. | moderate | <ul style="list-style-type: none"> • excellent intuitive clarity • allows task to be assigned to more than one cluster |

training factor measure will be created for each equipment by averaging across all the tasks associated with that equipment item in the data base. Profile difference scores between the equipment items on the mean training factor ratings will then be created. These profile difference scores will provide a measure of the similarity of one equipment item to another. The profile difference scores will be entered into a cluster analysis routine, which will produce the equipment item groups to form the taxonomy.

Development of Training Type Allocation Guidelines. We will develop the Training Type Allocation Guidelines in a two-stage process. In the first stage, we will identify the percentage of time typically spent in training with each training type. For institutional training, MA&D/DRC personnel will extract this information from a representative set of POIs for each mission area. The POIs typically have sections summarizing the amount of time spent with different methods and different types of major media, such as training devices. We will simply extract the necessary information from the POIs and average them.

For unit training, we will obtain information on the time taken up by different types of training through the unit training survey described in Steps 6 and 11 (see information on survey p. 51). A section of this survey will ask unit training managers to estimate the percentage of time currently spent on different types of training.

In the second stage, we will estimate the percentage of time that each training type will use in training each task in the future (i.e., the 1988-1995 time frame). We will present the current percentages described above to individuals from the Army Training Board and Training Technology Agency and ask them to modify them to reflect expected future trends in Army training technology. These agencies play a critical role in shaping long-term training trends within the Army.

Models

Development of Training Time Prediction Model. To develop the training time prediction equations, we will conduct a series of regression analyses using the training factors as predictors and the time to train a task as a criterion. We will develop separate equations to predict institutional and unit training time within each mission area.

To develop the data for the regression analyses, we will select a sample of tasks for each mission area from the CODAP data base. We will extract data on the nine training factors

from this data base. We will obtain data on the time spent in training the tasks in initial training by examining the Program of Instruction for the initial institutional training course. (This course can be identified by examining the Trainer's Guide for the MOS associated with the task.)

We will estimate the annual amount of time spent in unit training from a survey questionnaire sent to unit training managers. We will use this same survey to determine the maximum time available to train all system tasks. Page 51 provides a more detailed description of the procedures employed in this survey.

Once we have collected data on training time, we will conduct a series of step-wise regression analyses using the institutional training time measures as criterion variables. In conducting the regression analyses, we will attempt to identify the minimum number of training factor variables needed to predict training time for each mission area. By minimizing the number of training factor variables, we can reduce the number of ratings that the users must provide.

Application of the Training Time Prediction Equations. The TCEA will assist the user in inputting data on the training factors included in the training prediction model. Once these data are entered, the TCEA will apply the regression equations to predict institutional and unit training time.

The TCEA will help the user identify "similar" tasks which already have training factor ratings. The TCEA will extract these ratings from CODAP and store them in an on-line data base called the Training Factor Rating Data Base. The system will automatically identify a "similar" task by matching task action and noun statements with the categories in Task and Equipment Taxonomies. The user can review or modify this assignment, or select another task from the Training Factor Rating Data Base. The user will be able to review the training factor ratings associated with the similar tasks - update them to reflect the new system's equipment design and system performance requirements.

Development of ATRRS Data Extraction Program. The program for extracting information from ATRRS will present no major technical problems. DRC already has the ATRRS user's manuals and the ATRRS data element description. The specific data elements from which we will extract data are MOS (data element E-YY), course number (CRS-NO), course title (CRS-TITLE), course annual student/trainee input capacity (ANN-CAP), and course length in days (CRS-DAYS). The course number code identifies which courses are initial training courses.

User Interface

As noted in the Product Requirements section, the TCEA must be designed for users with little or no computer background. Users must be able to implement the TCEA through easy-to-learn and use human-computer dialogue techniques. A number of researchers (e.g., Williges, 1986; Parrish, Gates, & Munger, 1981; Shaw and McCauley, 1985; and Smith & Mosier, 1984) have developed guidelines for developing such techniques. These guidelines are perhaps best summarized in Williges' general principles for user interface development (1986). They are:

- Compatibility Principle - Minimize the amount of information recoding that will be necessary.
- Consistency Principle - Minimize the difference in dialogue both within and across various human-computer interfaces.
- Memory Principle - Minimize the amount of information that the analyst must maintain in short-term memory.
- Structure Principle - Assist the analyst in developing a conceptual representation of the system structure so that he or she can navigate through the interface.
- Feedback Principle - Provide the analyst with feedback and error correction capabilities.
- Workload Principle - Keep the analyst's mental workload within acceptable limits.

During the development of detailed design specifications, we will generate user interface guidelines for the TCEA from a subset of existing guidelines in Williges (1986), Smith & Mosier (1984), etc. The guidelines will shape the development of new software and the selection of off-the-shelf software for the TCEA. To maintain a consistent user interface, we propose that the same guidelines be applied to all six (MPT)² products.

Hardware and Software Configuration

Final selection of a hardware and software configuration cannot occur until detailed design specifications are developed. More information is needed about users and the type of hardware and software available to them when the TCEA is implemented. It is also vital to know the (MPT)² concepts will be implemented. Ideally, all six (MPT)² products should use the same basic hardware and software. But consistency is particularly important

for (MPT)² products with the same primary users. The sections below outline our current view of the (MPT)² hardware and software configurations. They are based on an integrated assessment of MA&D/DRC's MPT concepts or the six (MPT)² products.

Potential Hardware Configuration

Our current concept of the (MPT)² computer configuration includes an MS-DOS-compatible microcomputer with at least 20 megabytes of hard disk storage, at least two megabytes of RAM, two floppy disk drives, a modem, and a 132-column printer. A large amount of external storage will be needed to store the large data bases associated with the (MPT)² products. A large amount of RAM is also needed to decrease response time and allow the simulation that is expected to occur in Products 1, 5, and 6. Ideally, the microcomputer would be based on at least an 80286 processor (i.e., an AT-class processor) and include an advanced color monitor. Depending on the mechanism chosen for menu selection, a mouse or a lightpen may also be part of the configuration.

Potential Software Configuration

By the time the (MPT)² products are coded, we expect MS-DOS version 5.0 to be available. To facilitate integration across products, all new software created for (MPT)² should be written in a single, highly structured language such as C. C, like Ada, has proven to be extremely machine-independent. MA&D has used C to implement Micro SAINT.

Off-the-Shelf Versus New Software. Several common software functions are expected to extend across most, if not all, the (MPT)² products. For example, all six aids will need a data base management system for storing and accessing data. Several products may also need spreadsheet software to perform simple calculations. Others, like the TCEA, may need communications software to access data bases that reside on other computers. Still other aids such as Products 1, 5, and 6 may need simulation software such as Micro SAINT to represent complex system-human interactions.

We can use two basic approaches to develop the (MPT)² software. We can either use off-the-shelf software product or develop new software. The advantage of off-the-shelf software is that it can drastically reduce software development and documentation costs. Although the cost savings would not significantly impact the next phase of (MPT)² (development of detailed design specifications), they could effect Phase 3 software development

greatly. Another advantage of off-the-shelf software packages is that they often include additional features or add-ons that go beyond (MPT)² minimum essential requirements at little or no additional cost. In addition, off-the-shelf software can be used for applications other than (MPT)².

The major disadvantage of off-the-shelf software is, of course, that software that can meet (MPT)² functional requirements might not exist. Another disadvantage is that it is often impossible to modify the user interface in off-the-shelf packages. Typically, one has to "take or leave" the user interface. If more than one off-the-shelf package is used, one runs the risk of having inconsistent interfaces. Another disadvantage of off-the-shelf software for a Government system such as (MPT)² is the proprietary nature of this software. In order to distribute the (MPT)² products successfully, users must be able to acquire the software associated with them at little or no additional cost. Many software companies will not grant the Government distribution rights to their software or will charge each Government agency using the product the full price.

Another related problem is that many Army organizations outside the R&D community have difficulty purchasing software that is not on the GSA list. Fortunately, many useful software products are being added to the GSA list. One such product is ENABLE™. ENABLE™ is an integrated software package with spreadsheet, graphics, data base management, telecommunications, and word processing modules. The ENABLE™ data base management system can store up to 65,000 records per file. Its spreadsheet can utilize up to 65,025 cells. Its graphics package produces high resolution black and white or medium resolution color graphics and can create graphics from the DBMS or spreadsheet module. ENABLE™ also has a Master Control module that provides a window to DOS and a built-in menu generation capability for up to eight windows. These windows can be sized, shaped, overlapped, or zoomed to full screen. ENABLE™ can be purchased from the GSA list for approximately \$400.

As we develop detailed design specifications for (MPT)², we will select an approach (new software versus specific off-the-shelf software) to implement the software components of each (MPT)² product. This approach must be congruent with the approach taken to develop other (MPT)² products.

TECHNOLOGY TRANSFER ISSUES

Training Strategy

Our goal is to design a set of automated (MPT)² tools that the user can implement immediately without external training. To accomplish this goal, we will (1) employ a user interface that requires very little computer experience (see "Description and Development of Automated Components," p. 74), (2) provide on-line help to explain alternatives, and (3) automate as many analytical and data collection activities as possible.

The only external training we believe may be necessary is a brief pamphlet. This pamphlet will describe the hardware and software needed to run the aid, how to load the aid onto the computer, and what input data (if any) users should have on hand before to use the aid. We also recommend developing a small manual on how to use the results of the aid in the acquisition process. The experienced MPT user will not need this training. Frequently, however, users with no background in the acquisition process or MPT must use the aid. Such users will need an overview of the acquisition process and how the aid can help them during the process. These inexperienced users will also need examples of product input and output.

Means for Achieving Institutionalization

During the development of design specifications for this product (Option 1), we will produce a detailed fielding plan for the product. This fielding plan will describe the distribution of the aid's methods, hardware, software, documentation, and training programs (media, instructors, etc.) to specify Army users in specific Army organizations. The plan will be analogous to the Materiel Fielding Plan for Army weapon systems. We will develop a draft of this plan during Option 1 and a final version during Option 2.

At the present time, we believe that successful implementation will, at a minimum, require the following activities:

Identification of Specific Users. We must identify specific users of each product and describe the specific MAP activities and documents the aid will feed. This will ensure that the product has a "real world" use. The section entitled "Product Requirements" describes our approach for accomplishing this.

Incorporation of Users in Product Development. To ensure that the product meets their needs, we will include users in the product development process. At a minimum, they should use the

product during the external demonstration that will take place during Option 2. Ideally, they should also review the final concept papers and the detailed design specifications from Option 1. We stand ready to help ARI coordinate user participation in product development.

Incorporation of Acceptability/Usability Requirements into Product Specifications. We have incorporated acceptability and usability requirements into the requirements specification for each aid (see "Acceptability/Usability Requirements", p. 15). These requirements include features that will make the product easy to use (e.g., clear documentation, on-line help, etc.). During design specification (Option 1), we will develop detailed user interface guidelines. To ensure a consistent interface, the same guidelines will be applied to every product.

Instruction of Key Personnel. We propose that key personnel receive detailed training at ARI headquarters immediately after ARI has accepted the aid. These key personnel will be individuals likely to become (1) experts in using the aid, (2) instructors in using the aid, and (3) consultants for ongoing applications of the aid. At the present time, we recommend that these key personnel be staff members from ARI's System's Research Lab, MANPRINT support personnel in ARI field offices, and MANPRINT Policy Office staff within DCSPER.

Demonstrate Aid at User Sites. We also recommend that the aid be demonstrated at all primary user sites by contractor personnel or the key personnel who were trained at ARI headquarters. These demonstrations would provide hands-on training in the aid software using "real world" examples, describe the benefits of the product, and show users how the product can help them produce MAP products.

Software Maintenance. Specific Army organizations must be identified that can continuously update software, documentation, and training to reflect user applications and evolving needs.

On-line Help. We recommend that a "hotline" be established to answer users' questions and document problems. The hotline would be like those used by commercial software vendors and the MANPRINT Policy Office.

Incorporation into Army Training Programs and Regulations. Army training courses for MANPRINT, project management, etc., must be modified to describe how the aid can help users during the MAP. Regulations and pamphlets in these areas must be modified in the same way.

Number of Person-hours to Apply Product

We estimate that it will take approximately 80 hours to apply the TCEA.

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APPENDIX A--SCRIPTS FOR AUTOMATED STEPS
SOFTWARE DEVELOPMENT PLAN

The MPT Decision Support System (DSS) will be developed using the time-proven system process that all successful software organizations employ. This process is outlined in MIL-STD-2167/2168 and DoD Standard 7935. To further ensure success, we have adapted the process described in these standards to meet this project's unique needs. The process, illustrated at Figure A-1, consists of three steps and the products resulting from them.

Step 1 - Requirements Analysis

The requirements analysis identifies the specific functions that the system must perform. High level functional requirements were identified in the concept papers. Detailed functional requirements will be developed in Phase 2, Detailed Design Specifications. The requirements will describe the context, constraints, and functional requirements. Context requirements include:

- The general requirements that the new system intends to meet;
- The environment in which the new system will exist;
- How the new system will interface with other systems;

- How this particular effort fits into any overall long range system development plan; and
- What new technology the effort intends to demonstrate.

The constraints identify:

- Technology limitations;
- Schedule;
- Funding;
- Physical configuration restrictions;
- Political restrictions; and
- The Statement of Work itself.

The functional requirements define the functions that will meet the stated goals within the stated constraints, including the inputs, controls, outputs, and mechanisms associated with each function.

Step 2 - Preliminary Design

The preliminary design establishes a design concept that meets the needs identified in the requirements analysis. We will conduct this design process early in Phase 2 of the project and submit it for ARI's approval. Once the design concept has been established, we can create a software development plan. This plan will be based upon the level of effort and resources required to implement the design concept. Although a preliminary design concept has already been proposed, the final concept may vary with actual user requirements. The software development plan includes a work plan specifying the tasks that must be conducted and the order in which they must be performed, the computer hardware and software resources needed to develop the system, and a detailed work schedule.

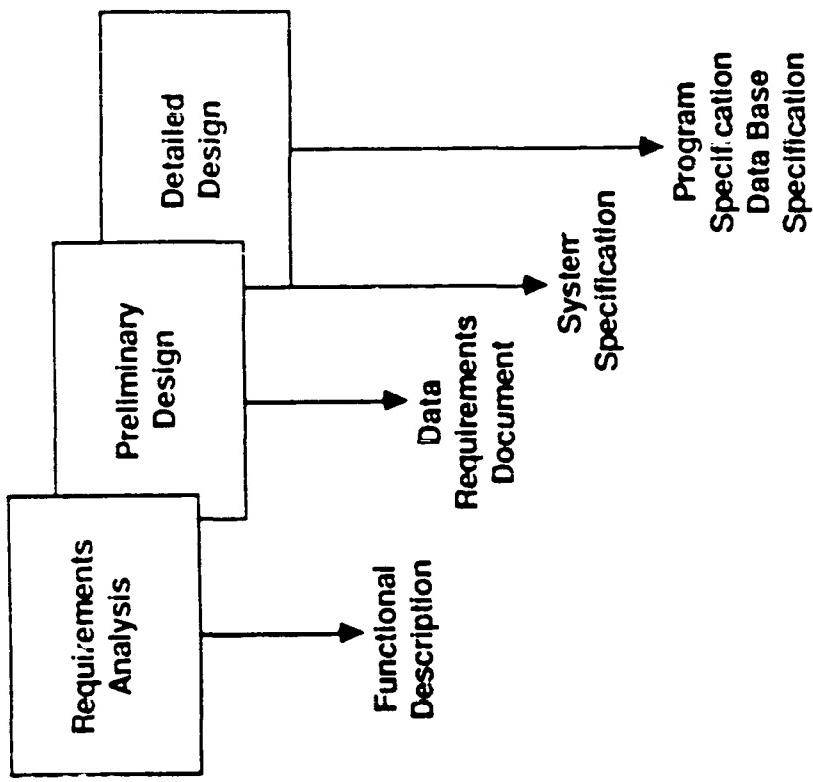


Figure A-1. The System Development Process.

DRC will use an automated program evaluation and review technique (PERT) to create and execute the software development plan. The PERT is an ideal technique for this project since it shows not only when each task is completed, but also how the tasks interrelate. The latter capability is extremely important in this effort because each segment of the DSS is dependent upon the others.

We will use an IBM PC (or other computer if desired by the COR) to create the software development plan and conduct the PERT analysis. Using a computer in this subtask is critical since the software development plan and the PERT network are complicated and must be updated continually throughout the rest of the project.

The final products of this subtask are a Preliminary Design Technical Report and the Software Development Plan. Although the contract does not require a Preliminary Design Technical Report, it is very important in the system development process. Step 2 consists of the following six activities:

Activity One - Prepare Preliminary Design

The preliminary design effort requires MPT research, system engineering, and ADP experience to generate a system design that will satisfy the user requirements. First, the project team translates the requirements into the outputs the system needs and develops the logic in arriving at these outputs. The process then dictates the input information needed to support the process. Next, the team establishes the analytical procedures to support the process. Finally, in order to define what resources will be required, the team establishes the ADP procedures (i.e., data base management,

general processing needs, etc.). The results of the design are documented in a Preliminary Design Technical Report that the COR and the technical members of the development group must approve.

Activity Two - Develop Task Plan

The development of the Task Plan (Software Development Plan) consists of determining the required tasks, the resources needed to accomplish these tasks, and a work schedule. In this activity we prepare the Work Plan, which describes the work to be accomplished and the order in which it must be accomplished. The key to developing a workable plan is having a detailed knowledge of the system development process and extensive experience in applying it to varying systems. The product of this effort is a work flow diagram that not only identifies the individual tasks, but also shows the interrelationships among them. Figure A-2 shows a typical diagram for a single program development effort.

Activity Three - Determine Required Resources

The resources needed to develop the system are determined based upon the products identified in Activity One and the tasks developed in Activity Two. These resources include manpower, computer hardware, computer operations, equipment, facilities, and materials. For a computer development project, this activity also includes analysis of off-the-shelf software resources needs versus newly developed software resources.

Activity Four - Develop Work Schedule

The final activity in determining the task plan is scheduling the work flow and the resources. The schedule must reflect the level of effort for each task, the availability of resources over time, and the interdependency of tasks and resources. Trade-offs may be made in the implementation schedules in order to use the resources more efficiently.

Activity Five - Conduct Critical Path Analysis

This activity uses PERT to combine the three activities above into a single critical path analysis. Using a network type of algorithm, the PERT procedure evaluates the interdependency of work packages, the expected time needed to complete each task, and the overall effect of varying these times on completing the project. The PERT process provides an excellent tool for developing the initial project development program. If properly maintained during the project, PERT allows continual updating of the project status and rescheduling of tasks to meet changing resource allocations and varying completion dates. We intend to apply the PERT process throughout the development of the Decision Support System.

Activity Six - Prepare Software Development Plan

The final activity in this subtask is preparing the Software Development Plan. The plan, prepared in accordance with ARI contract report guidelines, contains the information developed in Activities Two through Five and forms the basis of the software development.

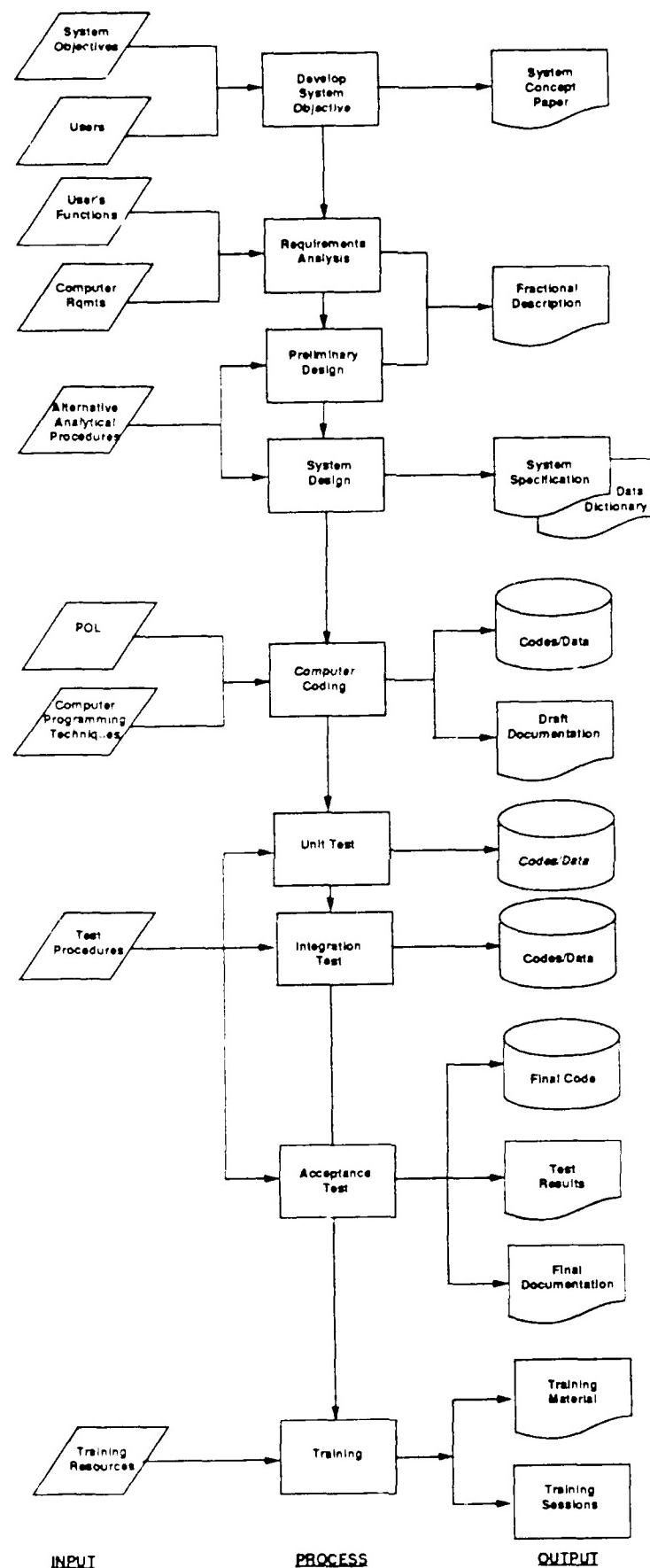


Figure A=2. Sample Work Flow Diagram for a Single Program Development Flow

Step 3 - Develop Detailed Design

The detailed design transforms the design concept into a highly detailed system design that is ready for computer application. During this step, the project team determines the specific analytical procedures and data handling procedures. Based upon the approved preliminary design, the project team prepares a detailed system design and determines if it is necessary to develop new software or acquire off-the-shelf software. The software is then developed or acquired, unit tested, and integrated with the total system. The team simultaneously determines the data requirements, constructs the data bases, and uses data base management systems. Next, the ARI staff tests the system to ensure that it meets the system-stated requirements before it is accepted. This test includes the review and approval of the system documentation. Finally, the system is implemented on the host computer, and ARI personnel are trained. We propose to hold this review at the end of Phase 2 of the project.

Detailed design consists of the following ten activities:

Activity One - Expand Preliminary Design Concept

This activity expands the preliminary design concept developed in Step 2. The expanded version includes a detailed description of the analytical procedures to be employed, the input needed to support the procedures, and the output resulting from the process. The detailed design is presented to the COR at the Critical Design Review (CDR) for approval.

Once approved, the design becomes the Critical Design Baseline. The detailed design specifications are considered the

"build-to" specification and are written at the level where a programmer can write code or adapt an existing software package without further design. During this activity, the team establishes the configuration management program and the guidelines for the system documentation.

Activity Two - Analyze Data Requirements

The detailed design conducted on Activity One determines the precise inputs required by the system, and the form of the output activity 2 is a data requirements analysis, done to determine the data elements that support the input and output. The analysis defines the source of the data, the means of collecting/transferring them to the system, and their management within the system. An important product of this activity is the Data Element Dictionary, which describes each data element by type, source function, and storage requirements.

Activity Three - Locate Existing Software

A key feature of our software development plan is to use existing software whenever possible. This approach drastically reduces the time and risk associated with developing new software, since off-the-shelf software has already been tested and proven effective. In this activity, we search for compatible off-the-shelf software that meets our design specifications. We may use available analytical programs as well as specialized models already developed (Micro SAINT). We also plan to use one of the many data base management systems (DBMSs) on the market to manage the data bases. Hopefully, much of this software can be used as is. If the software does not meet our precise needs, we

will adapt the existing code rather than attempt to build software from the ground up. We will build software only if we cannot find any existing programs, and we will ensure that the software we build is transportable and easily adaptable to similar problems.

Activity Four - Develop Unit Test Code

The most time-consuming task in software development is creating or revising computer code and unit testing it. We will develop code using common, standard, high-level programming languages that are highly reliable and transportable (such as FORTRAN and COBOL). All code, whether developed initially by us, adapted from code we have acquired, or taken directly off-the-shelf, must be unit tested to ensure that it meets the requirements Activity One established. The unit test, using test data generated for the unique purpose of unit testing, completes the computer development step and establishes the Segment Software Test Baseline.

Activity Five - Conduct Integration Test

The completed software segments are then tested as an integrated package using live data collected by the data base development effort. Once the Quality Assurance (QA) Testing Team has determined that the code meets the system requirements established in Subtask 2.1 and the standards of both the company and the Government, then the software becomes the Software System Test Baseline.

Activity Six - Conduct Acceptance Test

While the computer code is being developed and tested, the programming team prepares the system documentation according to the standards identified in Activity One. During the integration testing, the documentation is reviewed for completeness, accuracy, and conformity to the standards. After the QA team approves the documentation (as well as the integrated software), the system goes to the COR for acceptance testing. This time the COR will evaluate the software's accuracy, suitability, and usability using the following definitions:

Accuracy, or the model's ability to produce accurate results, is measured in terms of technical validity. Technical validity requires that the model's assumptions represent the real world it is intended to simulate, that the data used in the model is correct, that the mathematical formulations are appropriate and correct, and that the errors between the actual outcomes and predicted outcomes do not result from modeling parameters.

Suitability, or the extent to which the model's outputs satisfy the user's requirements, is verified using a requirements traceability matrix. During the requirements analysis, the detailed requirements are listed in a traceability matrix.

As the development continues, the requirements are traced through the preliminary design, the detailed design, the computer code, and the documentation. At

the Acceptance Test, the matrix is reviewed to identify each requirement in each development step and its presence in the final software and documentation.

Usability, or the model's usefulness in a realistic environment, is measured by the model's ability to conduct the analyses for which it was developed. This final criterion, typically called "operational validity", assesses the model's ability to produce results acceptable to the user.

Since the model cannot predict the real environment perfectly, operational validity must conclude whether the model's use is appropriate for the observed and expected errors.

Activity Seven - Implement Software/Train Users

The completed and approved system is then implemented on ARI's computer. To ensure its success, we will provide a formal training program for ARI. Build around the system documentation, the training describes the system's operation, preparation of the inputs, and use of the output. The training will include extensive hands-on training at the computer terminal, where most operations occur.

Activity Eight - Integrate Software

The analytical tools developed become part of the integrated (MPT)² system, through the integration of their operations and data. During this activity, the integration between this model and the decision support system tools (especially the Planner/Estimator and the Executor/Interpreter) is

established. Both the information required and the means of integration are described below.

Activity Nine - Evaluate Software

After our contract has ended, the using community will evaluate the software. This activity represents a separate function from the development process. It allows the user to become familiar with the system, while the developer is close at hand to provide assistance and, if desired, revise the model to correct any deficiencies in the original requirements and design. This activity is conducted in parallel with Activity Ten, which provides similar support.

Activity Ten - Provide Operational/Maintenance Support on (MPT)²

After the software is accepted by the user, a maintenance organization must continue to provide operational and maintenance support. This support includes demonstrating how to use the software in an operational environment, helping the user apply the software to actual operational problems, and maintaining the software on the host computer. Any revisions made to the computer code during this time will be reflected in the documentation.

APPENDIX B--FORMATS FOR ARMY REQUIREMENTS DOCUMENTS
OPERATIONAL AND ORGANIZATIONAL PLAN (O&O PLAN)

OPERATIONAL AND ORGANIZATIONAL PLAN (O&O Plan) FORMAT

The O&O Plan describes how a system will be integrated into the force structure, deployed, operated, and supported in peacetime and wartime. The concept establishes required readiness objectives and is the basis for Integrated Logistic Support planning. Initially, the plan should, as a minimum, describe any deficiencies which were identified in the MAA and any constraints applicable to systems development.

- I. Purpose - Describe the need for an operational capability to defeat the threat and eliminate an operational deficiency. State where in the MAA the deficiency is identified and how the need was developed from the described deficiency. (The need should be stated in broad characteristics only (e.g., a capability is needed to defeat enemy armor at "x" kilometers)).
- II. Threat/Deficiency - Describe the threat to be countered and the operational deficiency to be eliminated.
- *III. Operational Plan - Describe how, what, when, and where the system will be employed on the battlefield and how it will interface with other systems (attach Operational Mode Summary/Mission Profile as an annex). Communications support requirements should be addressed.
- *IV. Organizational Plan - Discuss the type units that will employ and support the system and when appropriate, the system(s) to be replaced. (When the system is decided on, include the number of systems estimated to be provided each type unit). This plan will support preparation of the BOIP, the Integrated Logistic Support Plan and identification of key ancillary items.
- *V. Personnel Impact - Design of the system should consider personnel skills available to operate and maintain the system. Generation of new MOS should be avoided where possible. (When the system is decided on, include an estimate of the number of people and skills estimated to operate and maintain the equipment, by type unit.) This plan will support preparation of the Tentative Qualitative and Quantitative Personnel Requirements Information (TQQPRI), the Personnel Support Plan, and assist in the LSA process.

Appendix B (Continued)

OPERATIONAL AND ORGANIZATIONAL PLAN (O&O PLAN)

OPERATIONAL AND ORGANIZATIONAL PLAN (O&O Plan) FORMAT (continued)

- *VI. Training Impact - Design of the equipment should consider type and extent of training required. (When the system is decided on, discuss the type and amount of training required and the need for training devices and simulators.) This plan will support preparation of the Training Support Plan.
 - *VII. Logistics Impact - System must be supportable by the Standard Army Logistics System and use standard tools and TMDE. (When the system is decided on, the proposed levels of maintenance, support concept, Test, Measurement, and Diagnostic Equipment (TMDE), Automatic Test Equipment (ATE), and Built-in Test Equipment (BITE) concepts will be discussed.) This plan will support preparation of the Integrated Logistic Support Plan.
- * - Complete information for these paragraphs may not be available when the initial O&O Plan is prepared.

Appendix B (Continued)

JUSTIFICATION FOR MAJOR SYSTEM NEW START (JMSNS)

JUSTIFICATION FOR MAJOR SYSTEM NEW START (JMSNS) FORMAT

Prepare JMSNS in the format shown below. Do not exceed 3 pages, including annexes. Identify any supporting documentation.

- A. Defense Guidance Element. Identify the element of Defense Guidance to which the system responds.
- B. Mission and Threat. Identify the mission area (numbers and title) and describe the role of the system in the mission area. Discuss the DIA-validated projected threat and the shortfalls of existing systems in meeting the threat. Comment on the timing of the need and the general priority of this system relative to others in this mission area. The TRADOC school or Integrating Center must obtain a DIA-validated threat from INSCOM early so as not to delay JMSNS preparation. The classification should be as low as possible; NOFORN data should not be included. DIA threat documentation should be referenced in lieu of higher classification. If the need is not threat driven describe the basis for the need (e.g., cost savings).
- C. Alternative Concepts. Describe the alternatives which will be considered (including product improvements) and, when appropriate, the alternative selected, the reasons for rejecting those that have not been selected, and any further tradeoffs that remain for the selected system.
- D. Technology Involved. Discuss maturity of the technology planned for the selected system design and manufacturing processes, when appropriate, with particular emphasis on remaining areas of risk.
- E. Funding Implications. Provide gross estimates of total RDT&E cost, total procurement cost, unit cost and life-cycle cost. Discuss affordability. See Appendix D, this Handbook, for funding format.
- F. Constraints. Describe, as applicable, key boundary conditions for satisfying the need, such as survivability; logistics, manpower and personnel constraints in both quantity and quality; standardization or interoperability within NATO or other DOD Components; and critical materials and industrial base required.
- G. Acquisition Strategy. Provide summary of salient elements of proposed acquisition strategy -- program structure, competition, contracting, etc.

Appendix B (Continued)

LETTER OF AGREEMENT (LOA)

LETTER OF AGREEMENT (LOA) FORMAT

The Letter of Agreement (LOA) will be in the format below. Limit information to that necessary for a HQDA decision. The basic document should not exceed four pages. In the LOA, use less detail and broader performance bands than in the ROC, JSOR, LR, and TDR. Terms in each paragraph of the LOA will evolve into more specific terms in the ROC, LR and TDR. Include in the LOA all alternative system concepts recommended for demonstration and validation.

1. TITLE

- a. Give a descriptive title for the program.
- b. CARDS reference number.

2. NEED/THREAT. State what is needed. Briefly describe the threat and operational/training deficiency need for the system. Include the enemy's capability to detect, identify, locate, avoid, suppress, destroy, or otherwise counter the system. Describe the responsive threat over time to support evolutionary development when applicable.

3. TIMEFRAME AND IOC. State the timeframe in which the new or improved system is needed.

4. OPERATIONAL & ORGANIZATIONAL PLAN: In a brief paragraph state --

- a. How the equipment will be used;
- b. Geographical areas of use;
- c. Weather and climatological factors to be considered during equipment operations;
- d. Battlefield conditions (such as ECM, smoke, and dust) in which the system will operate; and
- e. The type of units that will use and support the equipment.

Attach the mission profile to the LOA as an Annex.

5. ESSENTIAL CHARACTERISTICS. Describe only main operational features of the system. Included are counter-countermeasure capabilities, health, physical security, safety and human factors engineering requirements, and reliability, availability, and maintainability (RAM) requirements. Performance must be responsive to battlefield environmental conditions of continuous combat (such as full ECM, smoke, aerosols, rain, fog, haze, and dust).

Appendix B (Continued)

LETTER OF AGREEMENT (LOA)

LETTER OF AGREEMENT (LOA) FORMAT (continued)

Express performance and reliability characteristics in bands of performance. Those which are not suitable for banding will be stated as single values. During development, commercial, other service, NATO, or other allied nation characteristics of existing or programmed systems should be considered for inclusion. This will be with a view toward establishing a basis for interoperability, co-production, or standardization. Bands of performance should be flexible enough to consider competing systems of other services or allied nations. Stated bands of performance, or single value characteristics will be adjusted only after the combat and materiel developers agree that such changes are necessary. DCSOPS will approve changes for documents previously approved by DCSOPS. The requirements and provisions for the following must be considered.

- a. Interoperability;
 - b. Continuity of operations (CONOPS);
 - c. Security;
 - d. Reliability, availability, and maintainability (RAM) derived from mission performance parameters.
 - e. Standardization, including commonality for hardware and software to which the system will adhere;
 - f. Nonnuclear/nuclear survivability; NBC contamination/decontamination survivability;
 - g. Individual/collective protection equipment;
 - h. Adverse weather and reduced visibility conditions (smoke and obscurants) operations, and military operations on urbanized terrain (MOUT) where applicable;
 - i. Communications;
 - j. Operation transportability, such as: transportable in C-141 type aircraft requiring not more than...hours teardown and...hours setup by operator and crew, etc.
6. TECHNICAL ASSESSMENT. In the LOA, divide this paragraph into operational, technical, logistics, training, and manpower subparagraphs. In each, describe what the combat and materiel developers, logistician, trainer, and personnel administrator must do to produce the total system. Include a listing of major events and dates.

Appendix B (Continued)

LETTER OF AGREEMENT (LOA)

LETTER AGREEMENT OF AGREEMENT (LOA) FORMAT (continued)

7. LOGISTICS SUPPORT PLAN. Briefly describe the logistics support plan. The logistics support plan will be available for evaluation during OT I.

8. TRAINING ASSESSMENT. Discuss the need for system training devices. When required include description as an annex. (See p. 6.20 for format.) New Equipment Training (NET), operator and maintenance personnel training, and technical manuals and training material requirements will be stated in terms of needs for both the institution and unit training levels. The training support plan will be available for evaluation during OT I.

9. MANPOWER/FORCE STRUCTURE ASSESSMENT. Estimate manpower requirements per system, using unit, and total Army by component (Active, ARNG, USAR). Identify manpower savings resulting from replaced systems, if any. Include a statement to require an assessment of alternatives to reduce manpower requirements and an assessment of force structure implications resulting from system inclusion in the total force by component. If the force structure assessment exceeds current programmed force structure levels then identification of force structure tradeoffs within mission area or mission elements are required. Tradeoffs analyses are addressed to the degree necessary to bring the force structure assessment within current programming levels, if possible. The personnel support plan will be available for evaluation during OT I.

10. RATIONALIZATION, STANDARDIZATION, INTEROPERABILITY. Discuss other Services, NATO, and other foreign interest in the program. Identify similar programs contemplated by other services, NATO or other allies.

11. LIFE CYCLE COST ASSESSMENT. See appendix I.

12. MILESTONE SCHEDULE. A listing of significant events with dates to occur between approval of the LOA and next scheduled milestone review. The following should be included: LOA approval, DT/OT/other test (Market/User Survey for OTS), and next scheduled milestone review.

APPENDIX I - Life Cycle Cost Assessment - Provide life-cycle costs using mainly summary parametric estimating techniques. State the major life-cycle phases of R&D, investment, and operation and support. Also include the design to cost goals. As much as possible, show the estimated cost of major items or components below the system level. These data should be consistent with the Materiel System Requirements Specification (MSRS) and Baseline Cost Estimate (BCE).

Appendix B (Continued)

LETTER OF AGREEMENT (LOA)

LETTER OF AGREEMENT (LOA) FORMAT (continued)

ANNEX A - Coordination. List all major commands, other Services, allied nations, and activities with whom the LOA was coordinated. Provide full rationale for nonacceptance of comments, if any.

ANNEX B - Operational Mode Summary/Mission Profile Annex. List tasks and conditions for frequency and urgency viewed for system employment in military operations. The mission profile is logically derived from the O&O Plan. It provides the starting point for developing the system characteristics. See p. 5.23 for format for mission profile.

ANNEX C - COEA Annex. Executive summary of the COEA. Classify as required. Withdraw after HQ TRADOC approval of the LOA and handle as a separate document for transmittal as needed.

ANNEX D - Rationale Annex. Support various characteristics stated in the LOA. This provides an audit trail and rationale for determining how the characteristics were derived.

ANNEX E - RAM Rationale Annex. Executive summary of the RAM Rationale Report. Support the stated RAM characteristics with a logical argument that begins with the task frequency, conditions and standards described and analyzed in the MAA. This provides an audit trail and rationale for determining how the characteristics were derived. TRADOC/DARCOM Pamphlet 70-11 contains guidance on the preparation of both the RAM Rationale Report and the RAM Rationale Annex.

ANNEX F - Training Devices. When required, include description of needed training devices in format on p. 6.20. A separate annex is required for each training device.

NOTES:

1. All annexes will accompany the LOA until it has completed TRADOC and DARCOM staffing.
2. Send A, B, and F with the LOA when forwarded to HQDA for approval.

Appendix B (Continued)

REQUIRED OPERATIONAL CAPABILITY (ROC)

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT

The Required Operational Capability (ROC) is in the format below. Limit information to that necessary for a HQDA decision. The basic document should not exceed four pages.

1. TITLE

- a. Give a descriptive title for the program.
- b. CARDS reference number.

2. NEED/THREAT. Briefly describe the operational/training deficiency need for the system and the reactive threat to the system. Include the enemy's capability to detect, identify, locate, avoid, suppress, destroy, or otherwise counter the system. Describe the responsive threat over time to support evolutionary development when applicable.

3. TIMEFRAME AND IOC. State the IOC date including IOCs for successive evolutionary models, when appropriate.

4. OPERATIONAL AND ORGANIZATIONAL PLAN (O&O Plan). In a brief paragraph state:

- a. How the equipment will be used;
- b. Geographical areas of use;
- c. Weather and climatological factors to be considered during equipment operations;
- d. Battlefield conditions (such as ECM, smoke, and dust) in which the system will operate; and
- e. The type of units that will use and support the equipment.

5. ESSENTIAL CHARACTERISTICS. Describe only main operational features of the system. Included are counter-countermeasure capabilities, health, safety and human factors engineering requirements, and reliability, availability, and maintainability (RAM). Performance must be responsive to battlefield environmental conditions of continuous combat (such as full ECM, smoke, aerosols, rain, fog, haze, and dust).

Express performance and reliability characteristics in bands of performance. Those which are not suitable for banding will be stated as single values. During development, commercial, other Service, NATO, or other allied nation characteristics of existing or programmed systems should be considered for inclusion with a view toward establishing a basis for interoperability, co-production, or standardization. Bands of performance should be flexible enough to consider competing systems of other Services or allied nations. Stated bands of performance, or single value characteristics are adjusted only after the combat and

Appendix B (Continued)

REQUIRED OPERATIONAL CAPABILITY (ROC)

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT (continued)

materiel developers agree that changes are necessary. DCSOPS will approve changes for documents previously approved by DCSOPS. The requirements and provisions for the following must be considered:

- a. Interoperability;
 - b. Continuity of Operations (CONOPS);
 - c. Security;
 - d. Reliability, availability, and maintainability (RAM) derived from mission performance parameters;
 - e. Standardization, including commonality for hardware and software to which the system will adhere;
 - f. Nuclear survivability; NBC contamination survivability;
 - g. Individual/collective protection equipment;
 - h. Adverse weather and reduced visibility (smoke and obscurants) operations, and military operations on urbanized terrain (MOUT) where applicable;
 - i. Communications.
 - j. Operation transportability requirements, such as: transportable in C-141 type aircraft requiring not more than....hours teardown and....hours set by operator and crew; etc.
 - k. P3!
6. TECHNICAL ASSESSMENT. In the ROC, include a brief paragraph about the technical effort required. Address major areas for full scale development in terms of scope, technical approach, and associated risks in high, medium, low, or similar categories. For NDI items, briefly outline completed or planned market survey efforts and/or military suitability evaluations.
7. LOGISTICS SUPPORT PLAN. Briefly describe the logistics support concept. The logistics support package will be tested during OT II.
8. TRAINING ASSESSMENT. Discuss the need for system training devices. When required, include description as an annex to the ROC. (See p. 6.16 for format.) New equipment training (NET) operator and maintenance personnel training, and technical manuals and training materiel requirements will be stated in terms of needs for both institution and unit training levels. The training support package will be tested during OT II.
9. MANPOWER/FORCE STRUCTURE ASSESSMENT. Estimate manpower requirements per system, using unit, and total Army by component (Active, ARNG, USAR). Identify manpower savings resulting from replaced systems, if any. Include a statement to require an assessment of alternatives to reduce manpower requirements and an assessment of force structure implications resulting from system inclusion in the total force by component.

REQUIRED OPERATIONAL CAPABILITY (ROC)

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT (continued)

If the force structure assessment exceeds current programmed force structure levels then identification of force structure tradeoffs within mission area or mission elements is required. Tradeoffs analysis are addressed to the degree necessary to bring the force structure assessment within current programming levels, if possible. The personnel support package will be tested during OT II.

10. STANDARDIZATION, INTEROPERABILITY. Discuss other Service, NATO, and other foreign interest in the program. Identify similar programs contemplated by other Services, NATO or other allies.

11. LIFE CYCLE COST ASSESSMENT. See appendix 1.

12. MILESTONE SCHEDULE. A listing of significant events with dates to occur between approval of the ROC and next scheduled milestone review. The following should be included: ROC approval, DT/OT/other test (Market/User Survey for OTS), and next scheduled milestone review.

APPENDIX 1 - Life-cycle Cost Assessment. Provide life-cycle costs using mainly summary parametric estimating techniques. State the major life cycle phases of R&D, investment, and operation and support. Also include the design-to-cost goals. As much as possible, show the estimated cost of major items or components below the system level. (These data should be consistent with the Materiel System Requirements Specification (MSRS) and Baseline Cost Estimate (BCE). (See app D, p. D.7, this handbook, for format).

ANNEX A - Coordination. List all major commands, other Services, allied nations and activities with whom the ROC was coordinated. Provide full rationale for nonacceptance of comments, if any.

ANNEX B - Operational Mode Summary/Mission Profile Annex. List tasks and conditions for frequency and urgency viewed for system employment in military operations. The mission profile is logically derived from the operational/training concept. It provides the starting point for developing the system characteristics.

ANNEX C - COEA Annex. Executive summary of the COEA. Classify as required. Withdraw after HQ TRADOC approval of the ROC and handle as a separate document for transmittal as needed.

ANNEX D - Rationale Annex. Support various characteristics stated in the ROC. This provides an audit trail and rationale for determining how the characteristics were derived.

Appendix B (Continued)

REQUIRED OPERATIONAL CAPABILITY (ROC)

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT (continued)

ANNEX E - RAM Rationale Annex. Executive summary of the RAM Rationale Report. Support the stated RAM characteristics with a logical argument that begins with the task frequency, conditions, and standards described and analyzed in the Mission Area Analysis (MAA). This provides an audit trail and rationale for determining how the characteristics were derived. TRADOC/DARCOM Pamphlet 70-11 contains guidance on the preparation of both the RAM Rationale Report and the RAM Rationale Annex.

ANNEX F - TRAINING DEVICE ANNEX. Include when appropriate. (See p. 6.20 for format.) A separate annex is required for each training device.

- NOTES:
1. Send annex A with each requirements document.
 2. Annex F (when prepared) must accompany the ROC to HQDA for approval as a package.
 3. Send the TBOIP/TQQPRI with the ROC to HQDA for approval. When the TBOIP/TQQPRI are not submitted, the transmittal letter will contain a statement about the projected submission date.

APPENDIX C - TMACS AND UNIT TRAINING
RESOURCE PLANNING PROCESS

Training Management Control system (TMACS) is a minicomputer-based system that determines the cost of training events. It helps Active Component commanders plan training, evaluate the resource impacts of training events, and record training accomplished and resources expended. TMACS is designed to be operated by soldiers with no previous experience in computer operation and uses minicomputers located at installation/division and brigade headquarters. Battalion personnel normally use TMACS minicomputers located at brigade.

TMACS uses three variables to estimate the cost of training events:

- The size and type of the participating organization.
- The cost factor of each vehicle and weapon used in each training event type. Cost factors are different for each unit or event type. They are obtained from the installation-level agencies such as the comptroller or G3. The comptroller is responsible for keeping the cost factors current.
- The usage factor (miles, hours, and rounds) of each vehicle and weapon system used in each type of training event.

Training events used in estimating costs can come from the unit's long-range and short-range planning calendars. Examples of battalion-level events used for estimating resource requirements include: individual weapons training, squad training and evaluation, crew-served weapons training, and battalion Field Training Exercises (FTXs). Examples of activities used to estimate resource requirements above battalion level include: brigade Emergency Deployment Readiness Exercises (EDREs) and brigade, division, or corps Command Post Exercises (CPXs) and FTXs.

Output from the TMACS is fed into the command operating budget (COB). Budget guidance received from higher headquarters goes into the command operating budget. Commanders typically use the COB input to prepare long-range plans for unit training programs. This input contains budget estimates for upcoming training events. The COB is based on input from battalions and separate companies that are consolidated at higher levels between March and June of each year and forwarded to Department of the Army (DA) during July.

The COB is received at DA after Congress has approved the total budget. It serves as the basis for actual budget allocations. In both the Active Component (AC) and Reserve Component (RC), actual funding is received at the start of the fiscal year. AC and USAR funds are allocated through battalion and separate company. In the National Guard, the National Guard Bureau makes allocations to state headquarters. Funds are allocated based on the program analysis and resource review (PARR) and COB input. Unanticipated changes in fund priorities affect short-term planning.

The proponent for TMACS is the CG, FORSCOM. CG, U.S. Army Information Systems Software Support Command is the responsible agency for TMACS software.

The BTMS is the standard method for managing training in units. (See AR 350-1). The process consists of the planning, resource, training, and evaluation phases. TMACS is used in both the planning and resource phases of the BTMS. The following is derived from FM25-2:

- a. In the planning phase, the unit develops long and short-range training plans. The plans are developed from training needs, goals, and objectives identified in regulations, specified by higher commands, or determined by the unit commander's assessments of individual and collective training. The resulting plans are separated into training events. Each training event is entered into the TMACS using the event and ammunition worksheets and the tables and printouts provided. Training events are identified by training event category codes (TECCs) in the TMACS program. Each training event is considered either required or optional. Optional training events are given a priority based on the commander's guidance. Ammunition required for each training event is entered into TMACS in conjunction with the training event from the ammunition worksheet.
- b. In the resource phase, the unconstrained training program developed in the planning stage becomes constrained by funds allocated to the unit. The funding limitations for fuel and spare parts are input into the TMACS, and the Optimum Events Listing is printed. This printout will list resourced events and then nonresourced events. The unit commander or training officer optimizes the training program by using the

computer to adjust the projected numbers of vehicles, equipment, estimated mileage, and to obtain revised training events and reallocated resources. This process makes funds available for training events formerly on the nonresourced list. When the commander decides that the best training program is available relative to resources, the training program is passed to higher headquarters on a summary disk. The training programs required but nonresourced are forwarded to higher headquarters as unfinanced requirements. Higher headquarters may either reallocate funds, cancel part of the training requirements for that unit, or cancel the entire requirement.

- c. During the training phase, actual records of resources used are entered into TMACS to develop a historical data base. A summary report (the Closure Report) is an accurate review of the resources used to complete each training event. The data from the Closure Report is input to the TMACS as accomplished data. This process also coincides with the Execution Budget phase.
- d. The evaluation phase reviews the accomplished data in the data base and compares it to the planned events, the annual budget execution records, and the revalidation or change of equipment cost factors. This process assists in preparing future training programs.

Using the TMACS in preparing the training schedule of the command operating budget

- a. Projection of Program 2 Mission (Training) dollar requirements take place at the battalion or separate company level, is consolidated at successive headquarters, and is submitted

to HQDA. It represents the commanders' estimate of the resources required to perform the training mission.

- b. Annual instructions for preparing the training portion of the COB (Schedule 32 Instructions) are forwarded to MACOMs by HQDA. MACOMs supplement the instructions and pass them on to subordinate commands for completion. In providing the data required by the instructions, units use the software available in the TMACS for a portion of the requirements. Completed schedules are forwarded through channels and compiled by MACOMs. MACOMs forward summarized Schedule 32 Instructions to HQDA, where the data are used in the program objective memorandum (POM) cycle.
- c. To prepare the training schedule of the COB, the commander must first complete the yearly training plan as is done in the planning phase of the Battalion Training Management System (BTMS). Then, summaries of data can be produced for completing the Schedule 32 Instructions.